Chemical Engineering

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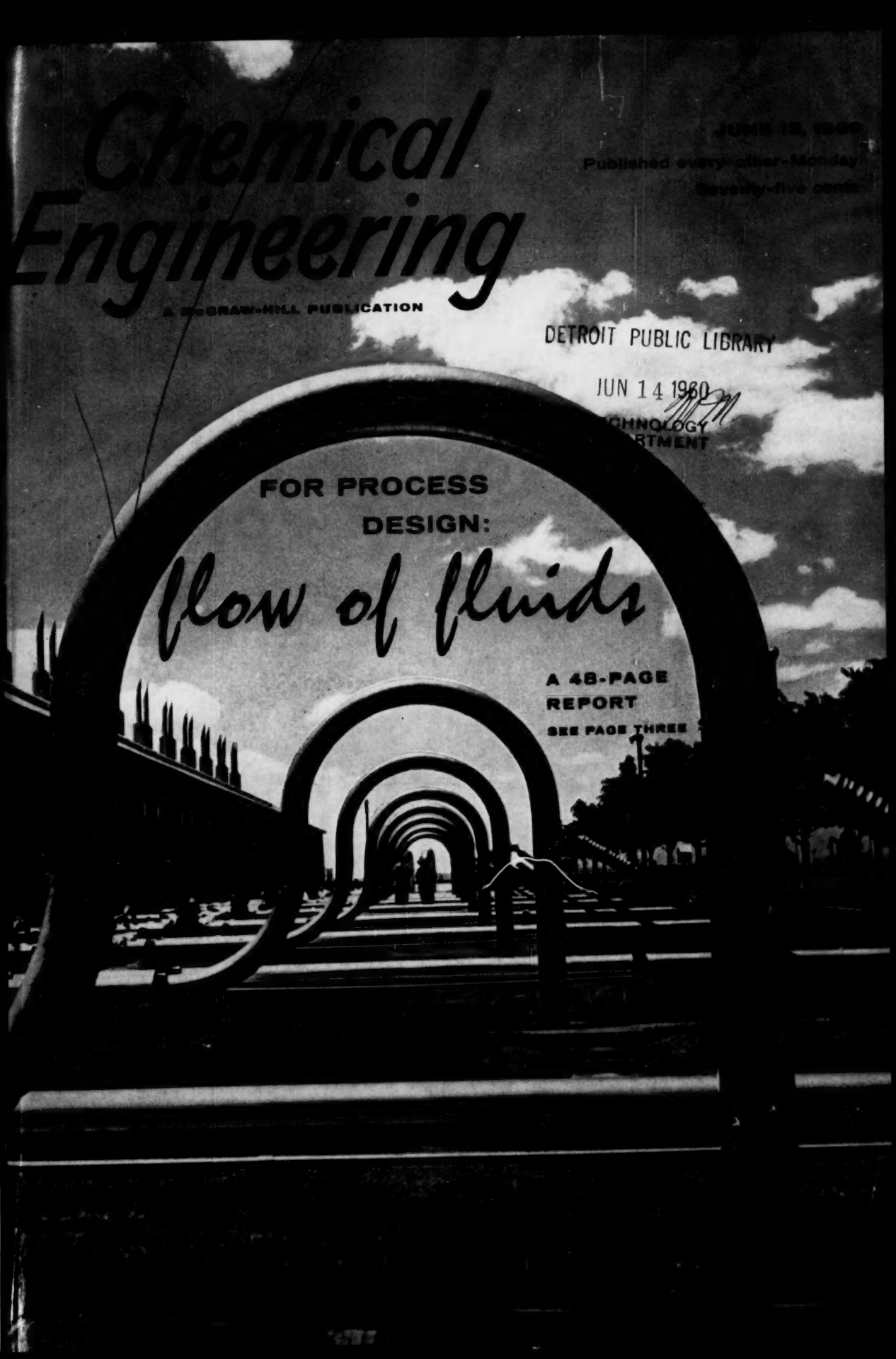

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flow of fluids

A 48-PAGE REPORT

SEE PAGE THREE

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1

ACETONE—low-boiling solvent that permits high solids concentration, particularly useful in high-low lacquer systems. Good for paint and varnish removers.

2

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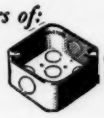
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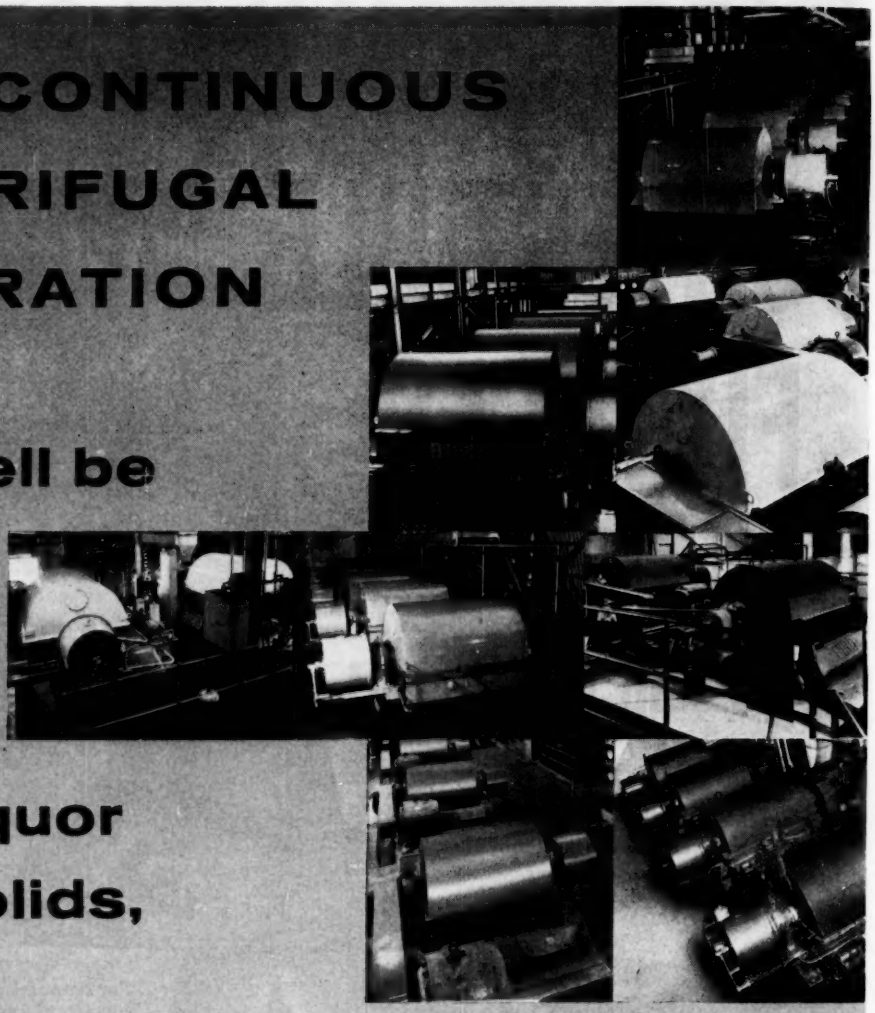

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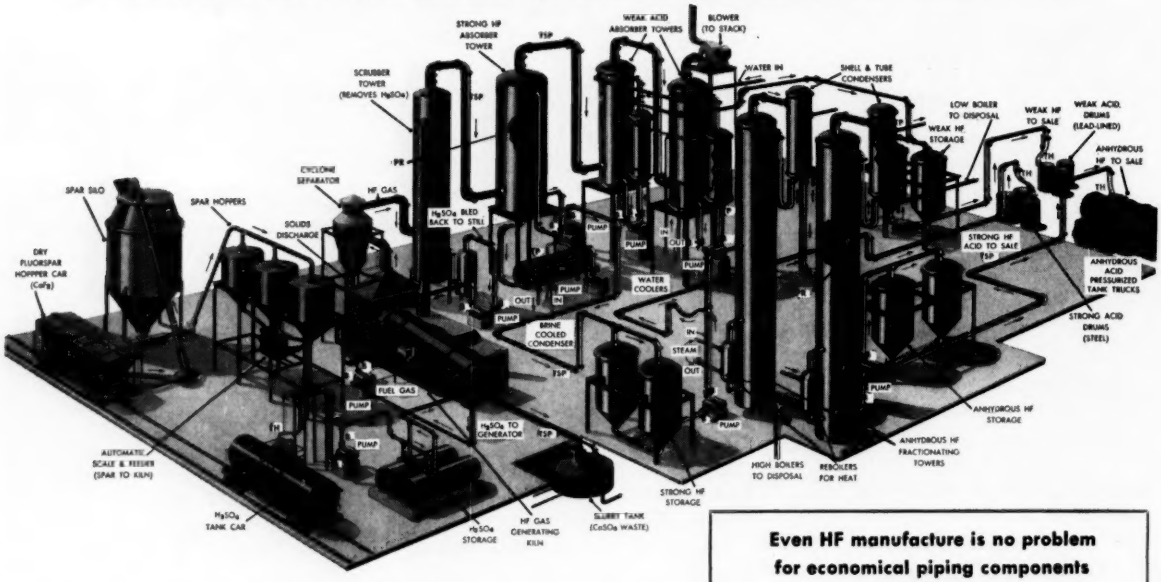

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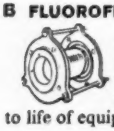

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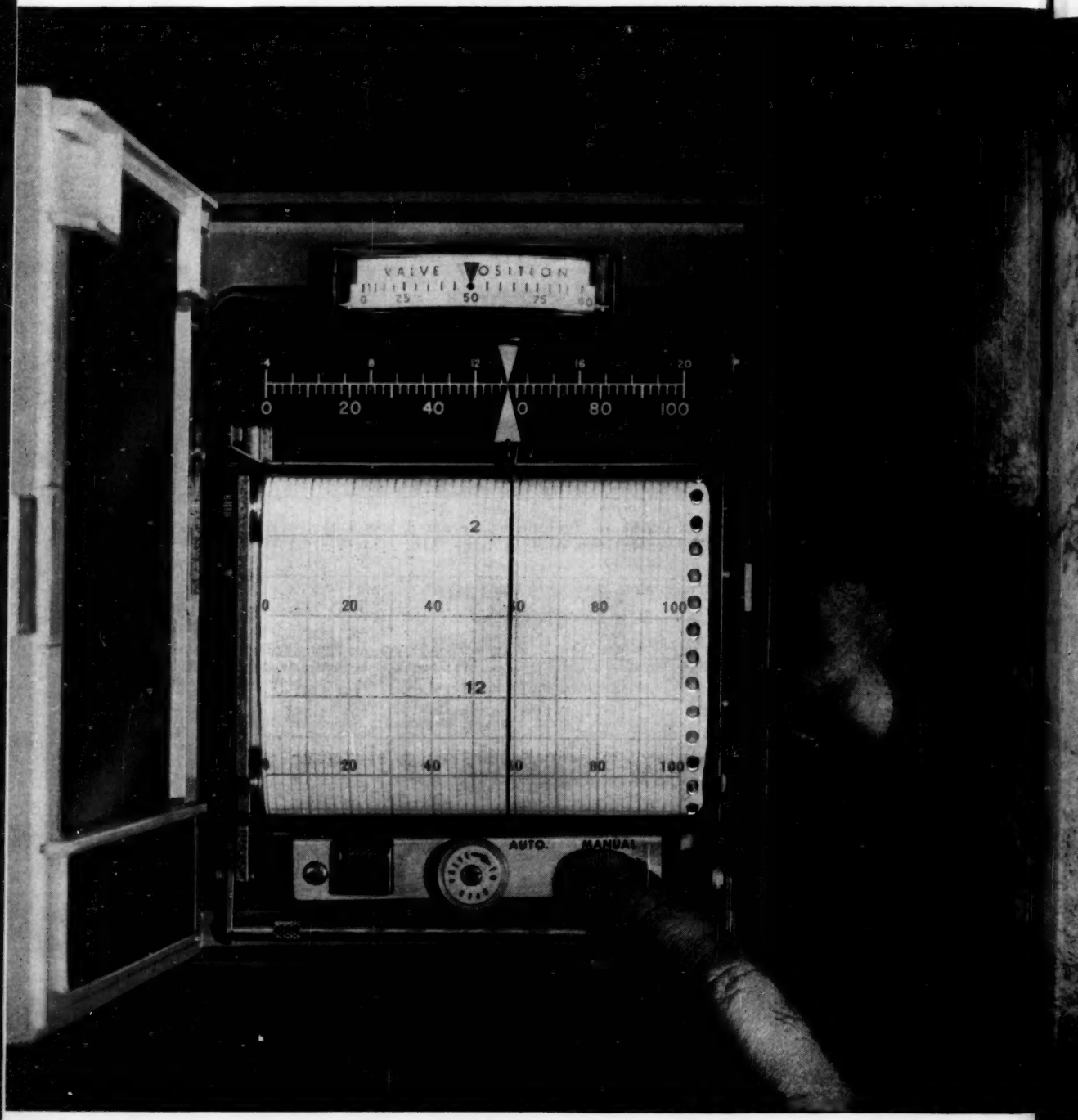

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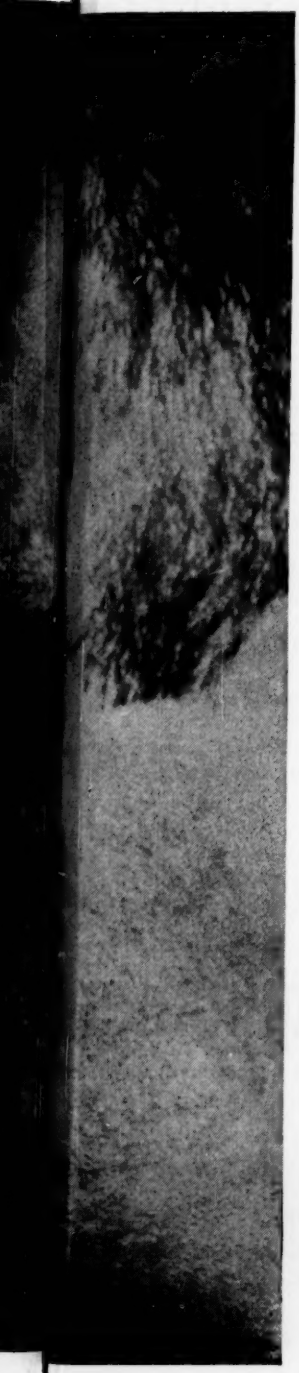

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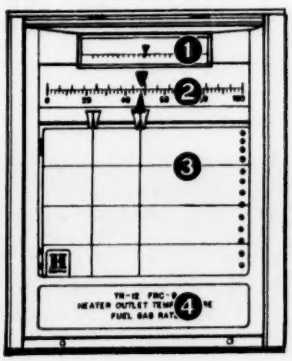

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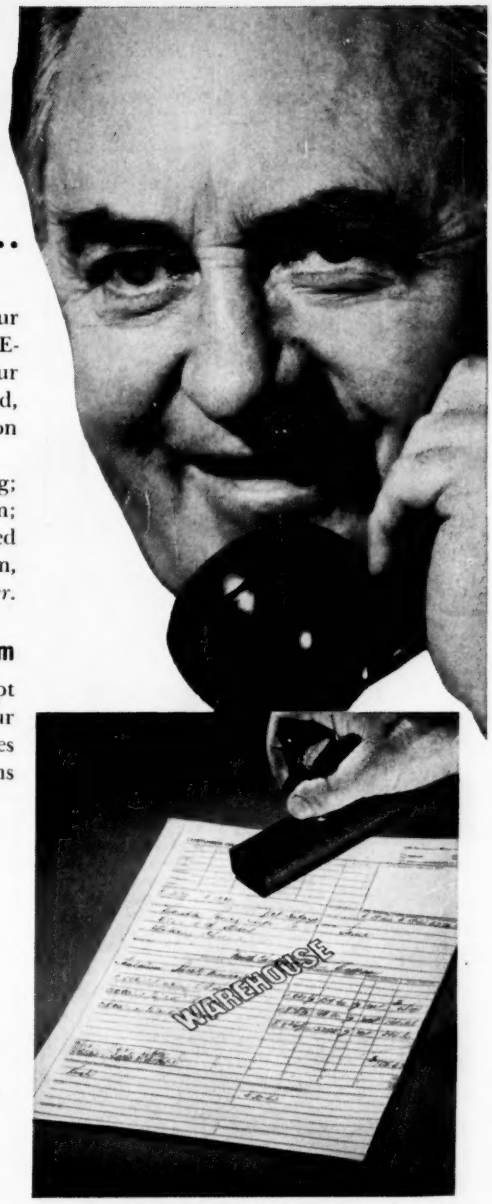

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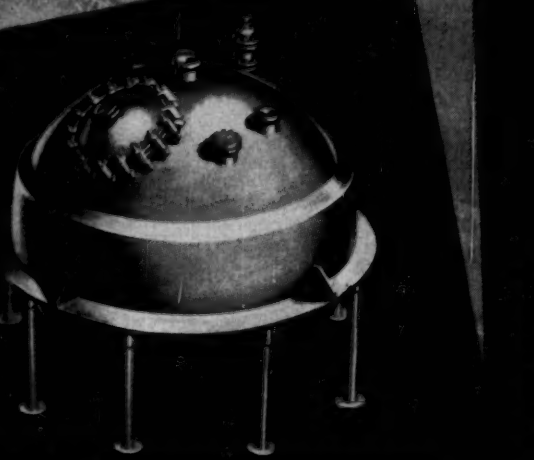

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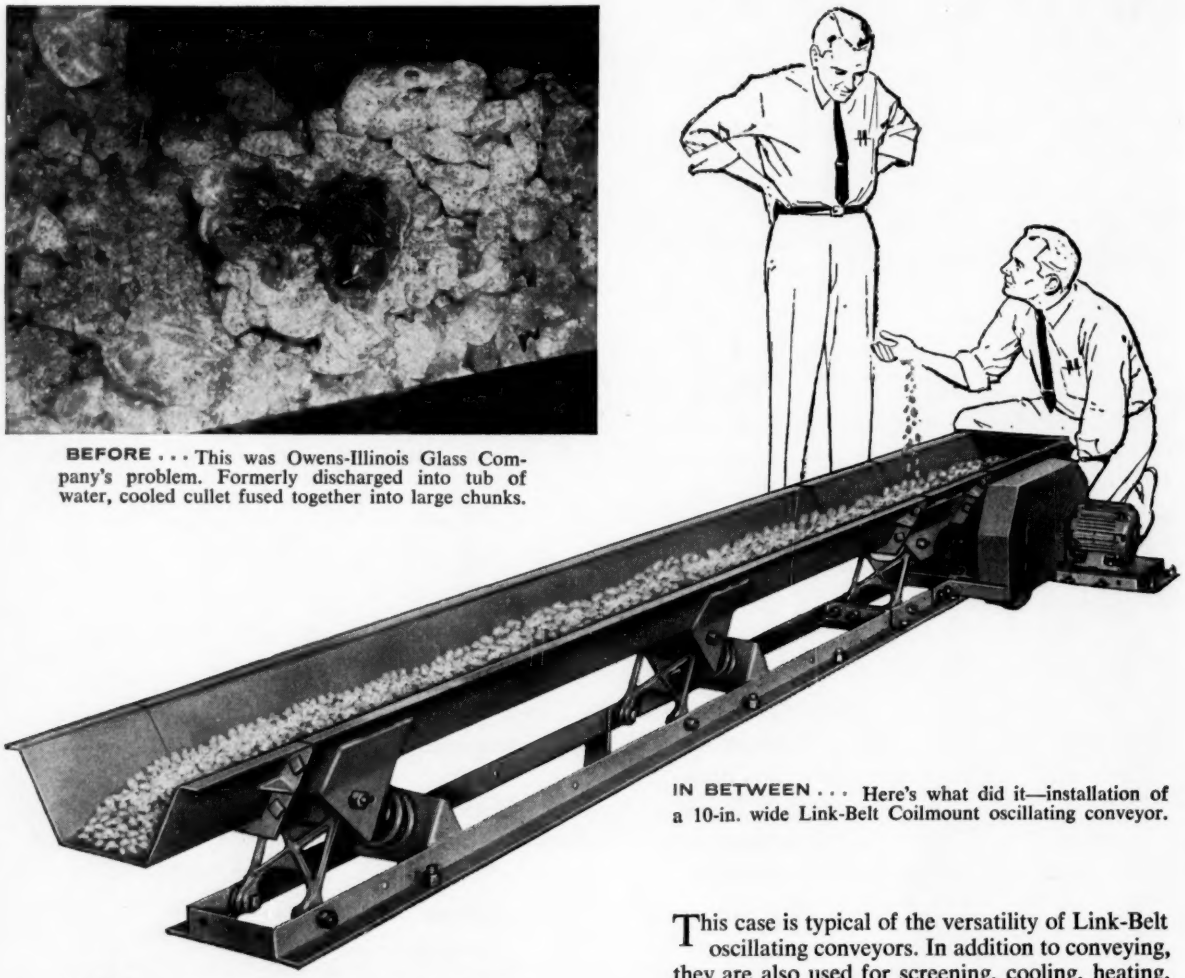

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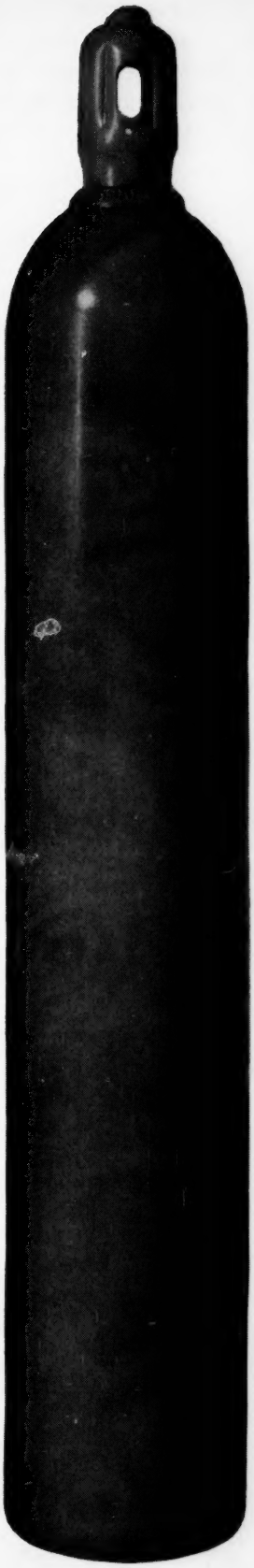

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—Clear, easy-to-read stamping eliminates errors.
—Uniform capacity simplifies filling and record-keeping.
—Complete range of sizes and shapes to meet requirements of all industries.
—Central shipping location means faster service, with favorable freight charges.

Hackney

Pressed Steel Tank Company

Manufacturer of Hackney Products

1447 S. 66th Street, Milwaukee 14, Wisconsin

Branch offices in principal cities

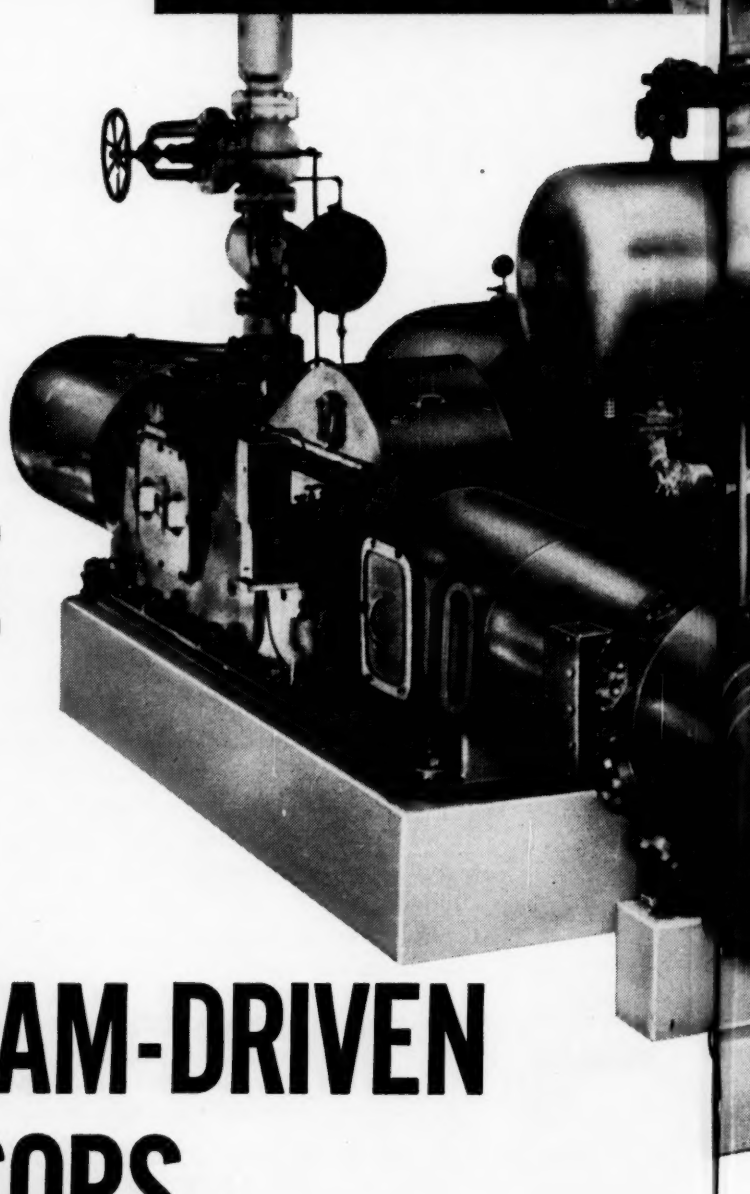
CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

Steam-driven compressors are still preferred where there is a need for exhaust steam for heating or process work, and where it is important to protect against shut-down in the event of electric power failure.

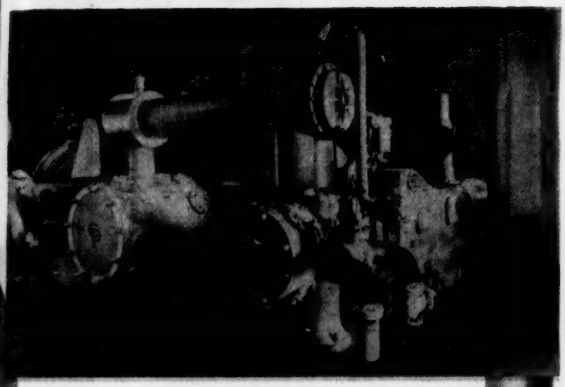
Chicago Pneumatic offers a complete line of steam-driven compressors from 20 to 1250 h.p., and for discharge pressures varying from vacuum to 15,000 p.s.i.g.

A battery of three Class H steam-driven compressors and two electrically-driven compressors installed in a prominent automobile manufacturing plant.

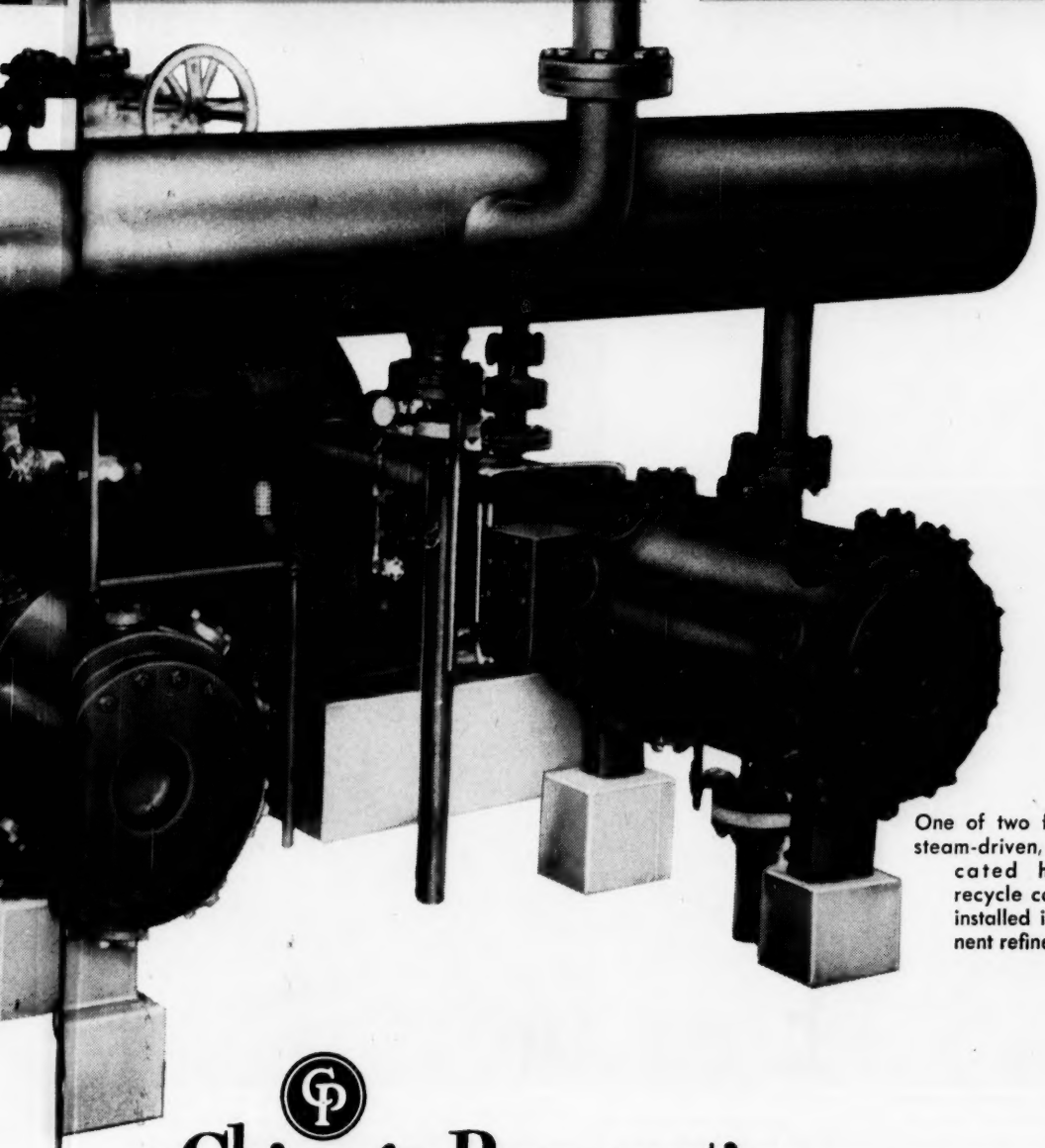
GET FULL VALUE FROM AVAILABLE STEAM... WITH CP STEAM-DRIVEN COMPRESSORS



Class H steam-driven compressor with simple steam end furnishing general refinery air.



Class H four-corner, steam-driven, single-stage booster compressor handling hydrocarbon gas.



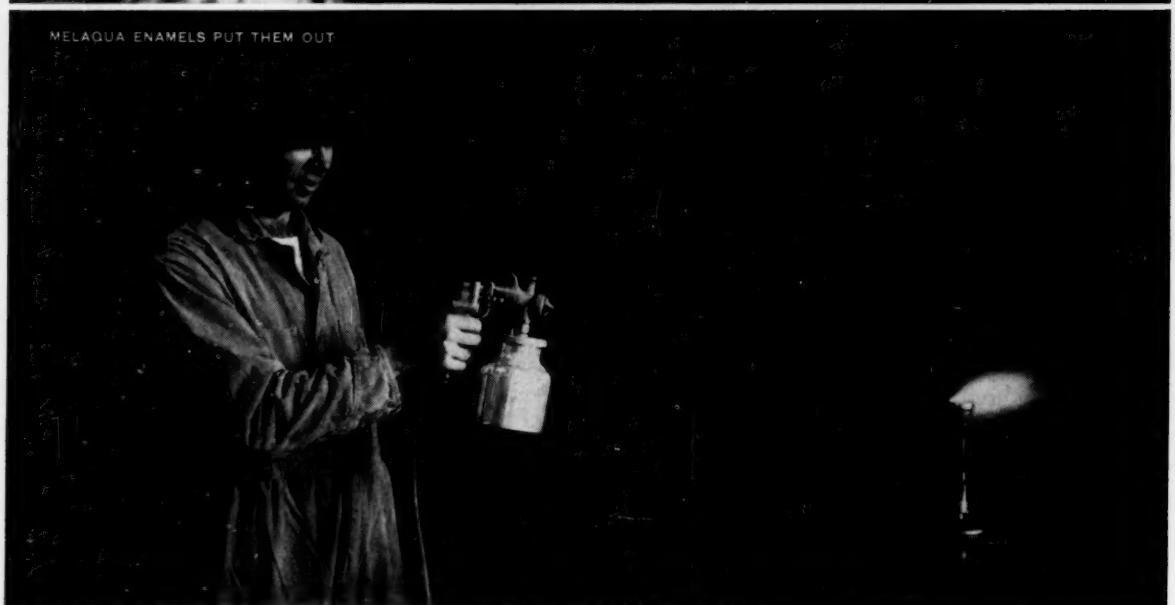
One of two four-corner, steam-driven, non-lubricated hydrogen recycle compressors installed in a prominent refinery.

Chicago Pneumatic *8 East 44th Street, New York 17, N. Y.*

AIR AND GAS COMPRESSORS • VACUUM PUMPS • PNEUMATIC TOOLS • ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS

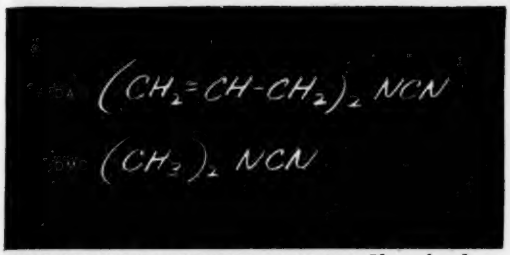
CYANAMID

Chemical Newsfront

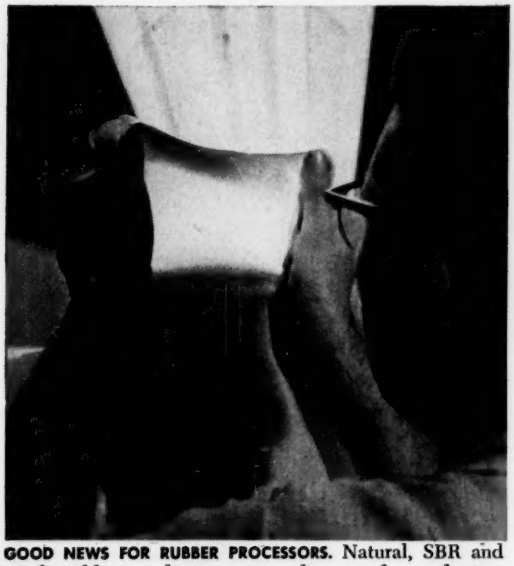


EXCITING NEW VEHICLE FOR BAKING ENAMELS is Cyanamid's MELAQUA* 600. This new product is a melamine-acrylic resin that produces a ready-to-spray enamel with only the addition of pigment and water. By excluding the use of solvents, Melaqua 600 completely eliminates fire hazards (see photos above). In addition to its safety factor, it gives the enamel such desirable qualities as exceptionally good flow and levelling, high gloss, and clearer, brighter colors than solvent enamels of the same pigmentation. Melaqua 600 enamels retain colors well under heat and light, have outstanding outdoor durability. Suggested uses for this new resin are full color, pastel metallescent industrial and automotive finishes.

*Trademark (Plastics and Resins Division)



DOOR-OPENERS TO NITROGEN CHEMISTRY. If you've been looking for a way to participate in the promising field of nitrogen chemistry, DIALKYL CYANAMIDES will prove helpful. Drum quantities of these compounds are available for the synthesis of substituted guanidines, biguanides, normal and isoureas, thioureas and secondary amines. Copolymers of *diallyl cyanamide* can be used as plasticizers, adhesives, molding, casting, and laminating resins, and for electrical insulation. *Dimethyl cyanamide* has unusual solvent properties – may also be used for hydraulic fluids and as a corrosion inhibitor.
(Market Development Department)



GOOD NEWS FOR RUBBER PROCESSORS. Natural, SBR and nitrile rubber products can now be manufactured more efficiently and economically – thanks to the excellent dispersibility of Cyanamid's new MBTS ACCELERATOR. The new MBTS makes possible such process savings as: shorter mixing cycles, lower reject rates, better dispersion, elimination of refining and master-batching. Its vulcanization and accelerating characteristics remain unchanged. Factory trials indicate that rubber processors get better and more uniform dispersion within the time cycle currently used for mixing. New MBTS is a high purity, light color product. **(Rubber Chemicals Department)**

NEW CATALYST TAKES THE FIELD. Cyanamid's new fluid cracking catalyst, AEROCAT® 3C*, is now undergoing extensive testing in the field. Composed of silica, alumina and magnesia, the new catalyst is designed for more flexible and profitable refinery operation. Its advantages over current silica-alumina compositions: yields more gasoline, more propylene and more butylene – produces less coke and dry gas. Aerocat 3C is available in two forms: Aerocat 3C-12 for high gasoline yield; Aerocat 3C-20 for high propylene and butylene yields.
Patent applied for.* **(Industrial Chemical Division)

CYANAMID

AMERICAN CYANAMID COMPANY
30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

All wool "Enchantress"—one of those heavenly carpets by Lees.

MORE AND LOVELIER CARPET COLORS. Here's good news for the carpet industry and its consumers: Cyanamid's new CALCO® LEVELING SALT LV eliminates objectionable striped or Barré effects encountered in dyeing wool carpeting – permits carpets to be dyed effectively in the widest range of colors ever! The agent also is expected to prove equally advantageous in dyeing nylon carpeting, hosiery and sweaters. When used with neutral dyes, Calco Leveling Salt produces deeper, level, solidly dyed shades on wool and/or nylon stocks, yarns and fabrics. Cyanamid's new agent allows the colorant to dye rather than stain the fiber. As a result, shades may be matched by adding color in process – not possible with other agents of this type. Calco Leveling Salt has no adverse effect on the fastness of the dyes used. **(Dyes Department)**

For further information on products in this advertisement wire, phone – or mail this coupon to:

AMERICAN CYANAMID COMPANY **CE-60**
30 Rockefeller Plaza, New York 20, N. Y.

Please send me additional information on

- ☐ MELAQUA 600
- ☐ MBTS ACCELERATOR
- ☐ CALCO® LEVELING SALT LV
- ☐ AEROCAT 3C
- ☐ DIALKYL CYANAMIDES

Name _____

Company _____

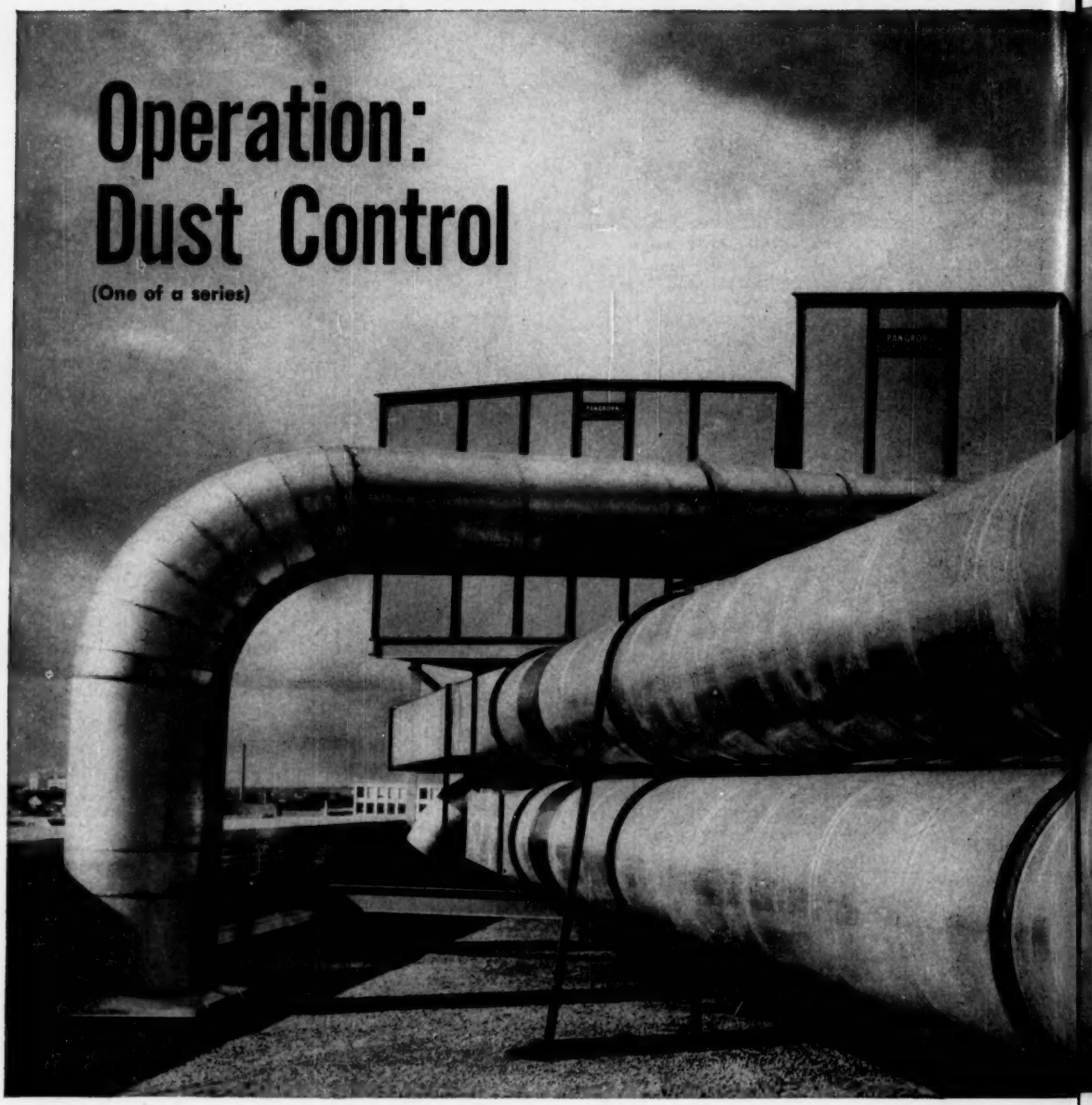
Position or Title _____

Address _____

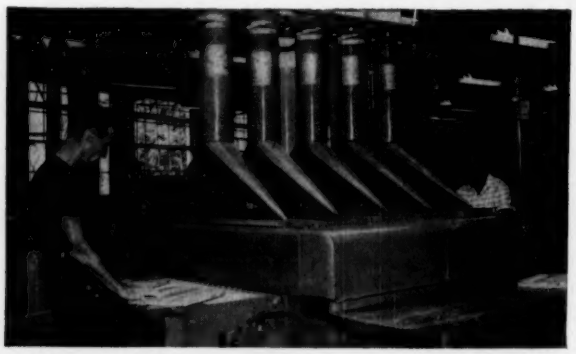
City _____ **Zone** _____ **State** _____

Operation: Dust Control

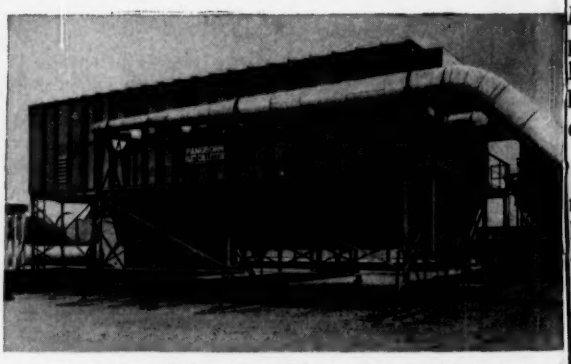
(One of a series)



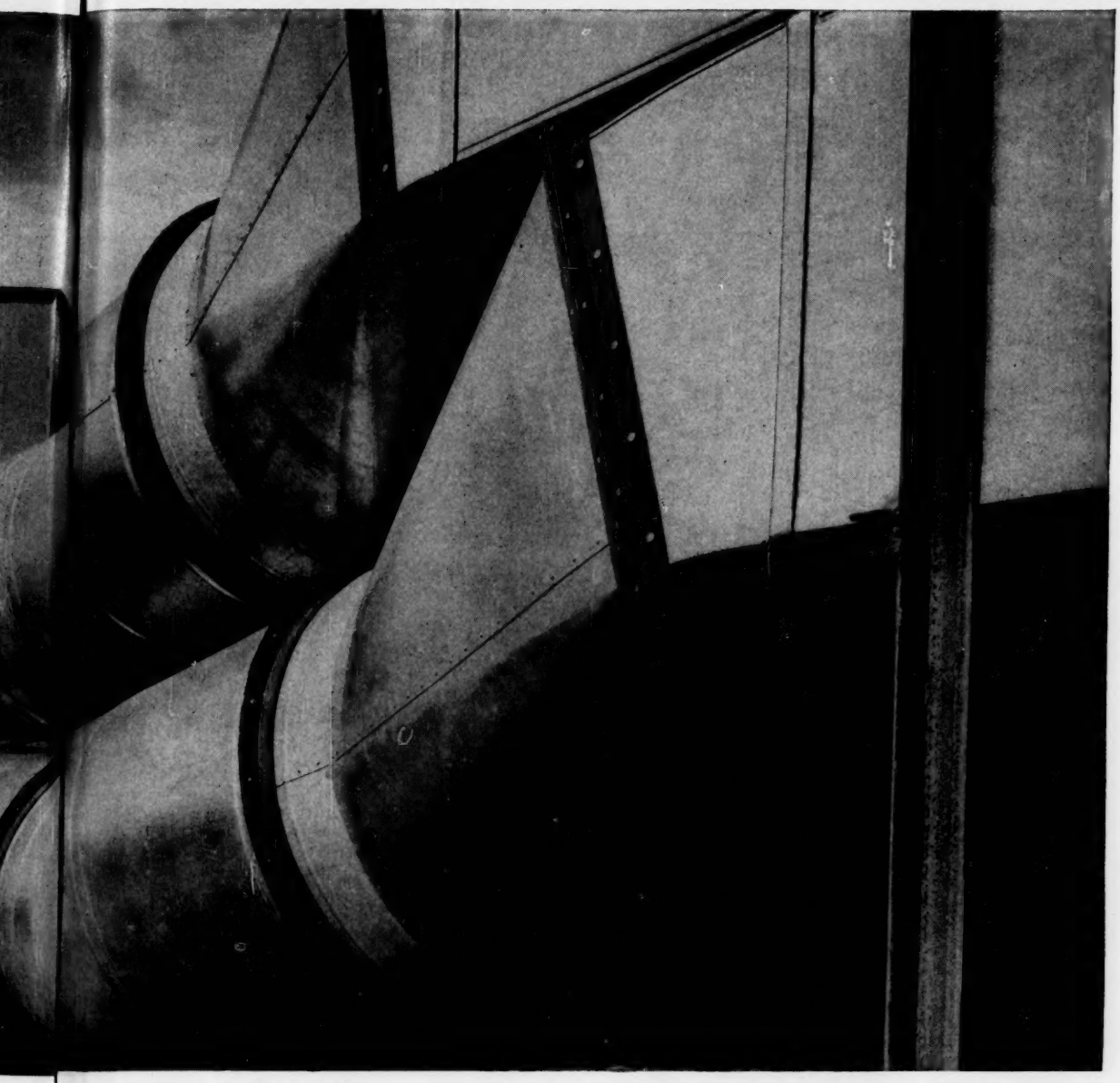
At National Cash Register, 10 tons of woods



Dust is trapped at the source by hoods engineered for the individual job . . .



. . . and is piped from 160 locations to five giant Pangborn Cloth Bag Collectors



...oodshavings, chips and dust are collected daily!

Mammoth is the word for the 5-floor woodworking plant of National Cash Register headquarters, Dayton, Ohio. Processing nearly 300,000 sq. ft. of lumber each month, this operation generates 10 tons of waste material per day.

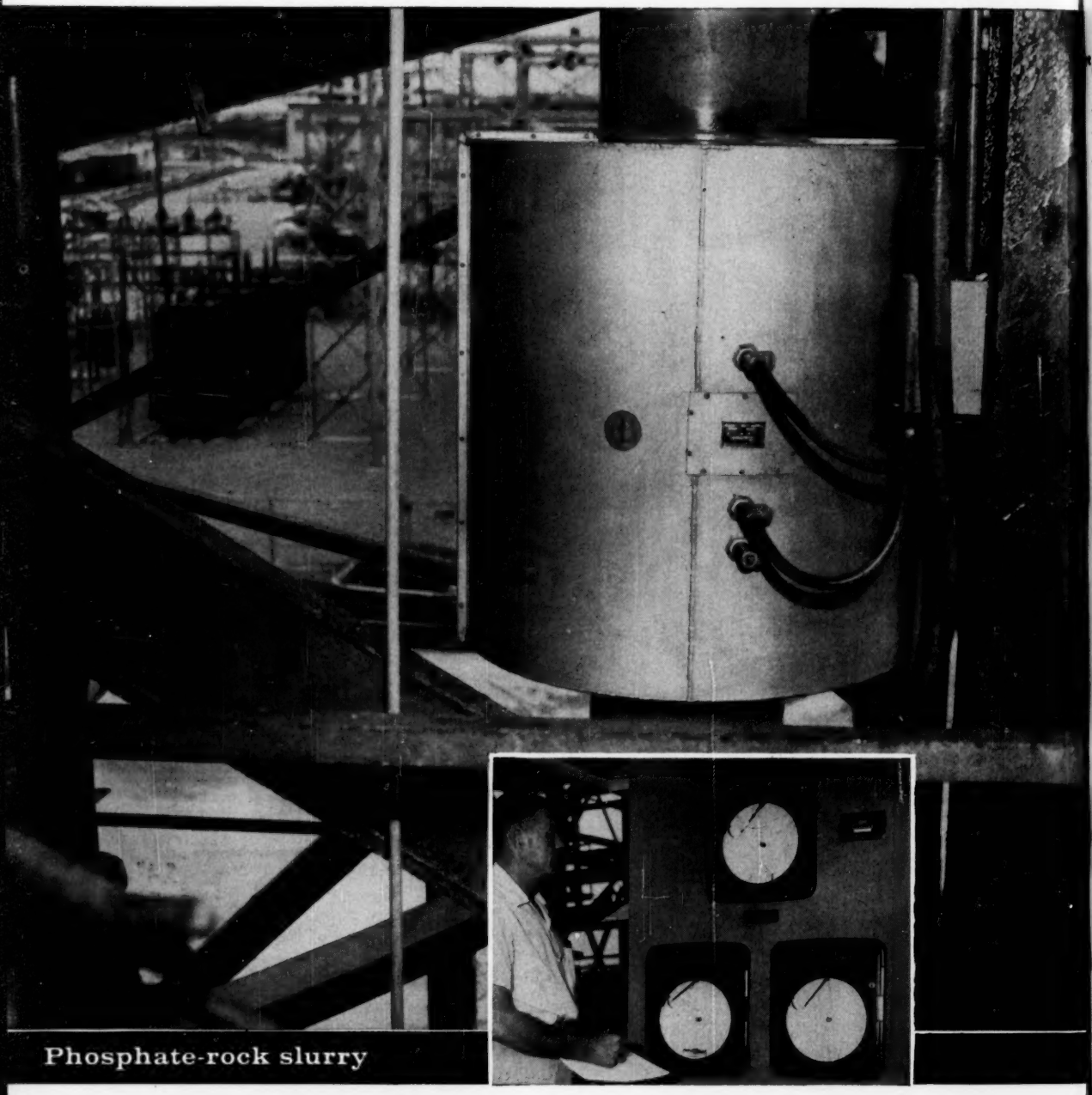
To protect NCR employees, equipment, plant and neighborhood, five Pangborn Cloth Bag Dust Collectors trap 90 cu. ft. of fine dust for disposal and, during the winter months, permit recirculating of the already-heated, cleaned air. This efficient performance of Pangborn Dust Control saves thousands of dollars in heating costs during the cold weather. In addition, a neighborhood and health nuisance has been eliminated; equipment maintenance and plant housekeeping costs have been minimized.

Dust a continuing problem in *your* plant? Talk to the Pangborn man in your area or write: PANGBORN CORPORATION, 2600 Pangborn Blvd., Hagerstown, Md. *Manufacturers of Dust Control, Blast Cleaning, Vibratory Equipment—Rotoblast® Steel Shot and Grit.®*

Pangborn
OF HAGERSTOWN

at International Minerals –

sand, acid, rock . . . nothing stops the



Phosphate-rock slurry

This 16" Foxboro Magnetic Flow Meter is part of a mass-flow system for measuring phosphate rock slurry pumped to flotation plant. Meter measures slurry in gpm, while nearby gamma ray density cell measures density of solution. The two variables are recorded separately, and their product is then recorded in dry-tons-per-minute on the third Dynalog instrument on the panel above. Recorder readings are telemetered to mine head so operators will know how much rock to feed into pipeline.

the Foxboro Magnetic Flow Meter

"One meter even paid for itself in 4 months" –

reports J. H. Andrews, senior development engineer

You'd travel a long way to find a process with as many meter-killing liquids as at International Minerals and Chemicals Corp., Bartow, Florida. Phosphate-rock slurries, sand-water slurries, phosphoric acid — yet they're all metered accurately, continuously with Foxboro Magnetic Flow Meters.

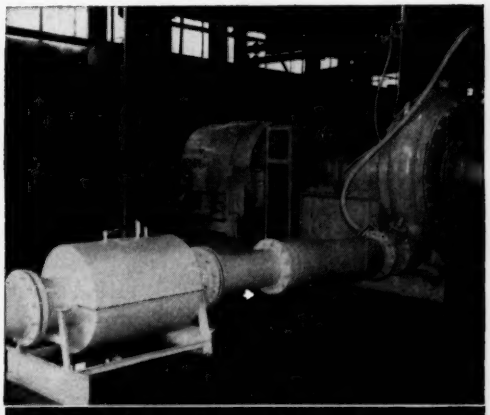
The Magnetic Meter is perfect for such "difficult liquids." It has no flow restrictions of any type — nothing to plug up. Instead, electrodes flush-mounted in corrosion-proof meter wall sense flow rate magnetically — send a linear proportional signal to a Foxboro Dynalog* Electronic receiver.

Magnetic Meters are installed as simply as a length of pipe — require no special meter runs, or straightening vanes. Maintenance is virtually nonexistent.

Ask your Foxboro Field Engineer for full details on the high-accuracy, low maintenance Magnetic Flow Meter. The Foxboro Company, 366 Neponset Ave., Foxboro, Mass.

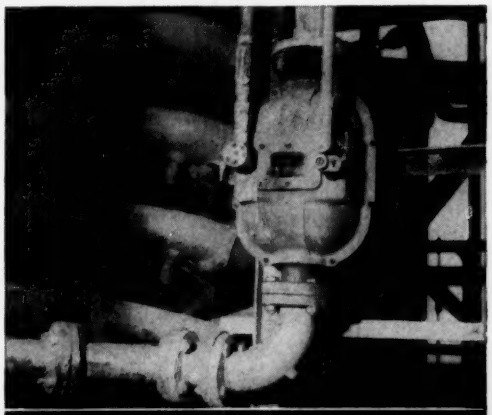
Reg. U. S. Pat. Off.

Write for Bulletin 20-14.



Sand-water slurry

International Minerals uses this 12" Foxboro Magnetic Flow Meter to control pumping rate of sand and water slurry. Foxboro Dynalog Controller holds pump discharge within ±1% of its 6000 gpm capacity. Slurry is so abrasive, entire pump unit must be replaced every six weeks. Only work done on Magnetic Meter, however, has been one "preventive maintenance" liner replacement during 3 years of continuous operation.



Phosphoric acid

One of six Foxboro 3" Magnetic Flow Meters at International's Bonnie Chemical Works. Meters measure phosphoric acid with better than ±1% accuracy. Although meters have been operating up to 4 years, under highly corrosive conditions, none have ever required maintenance.

FOXBORO

REG. U. S. PAT. OFF.

PACKAGING ENGINEER. To analyze your bagging requirements, and recommend the right packer from over 50 different models.

FIELD ENGINEER. To install and service packing equipment in the field, and to assist in bag size testing.

THE RIGHT BAG. From 13 bag manufacturing plants located in key areas throughout the country.

Behind each St. Regis® bag

The new St. Regis Bag Division was developed to provide the most complete service ever offered for companies that pack and ship their products by bag. It is so complete it is called *Packaging-in-Depth*—which means, simply, that St. Regis gives you, the bag user, the best bag service available anywhere.

Count on St. Regis for the best bag for your product, the best equipment to fill it, swifter delivery, the most complete engineering staff in the industry, and research and development

BETTER SERVICE. The bags you want, when and where you want them—multiwall, textile and WPPL.

MATERIALS HANDLING. To streamline your packing operation with the latest warehousing techniques and modern auxiliary handling equipment.

PACKAGE DESIGNER. To develop new packages to suit your needs, and discover more advanced, efficient packaging methods.

you buy...Packaging-in-Depth

facilities working constantly to improve your packaging.

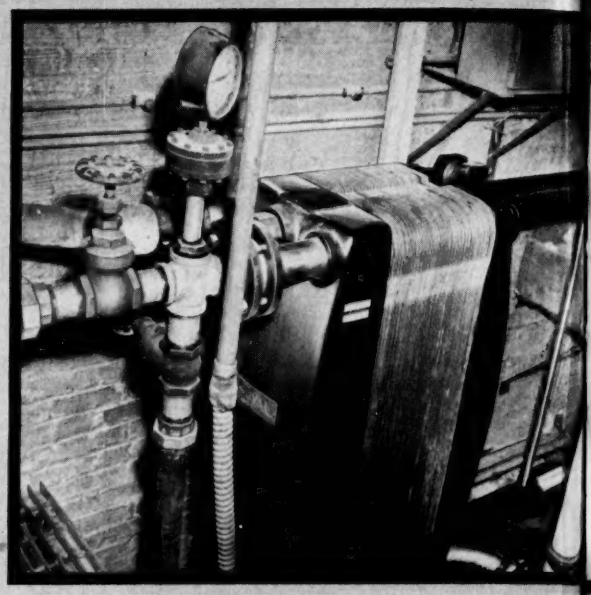
To sum up: our Bag Division now offers you the most *diversified* packaging service in the country through the most *specialized* people in the industry. Behind each St. Regis bag you buy stands the most complete bag service available . . . *Packaging-in-Depth!*

BAG DIVISION

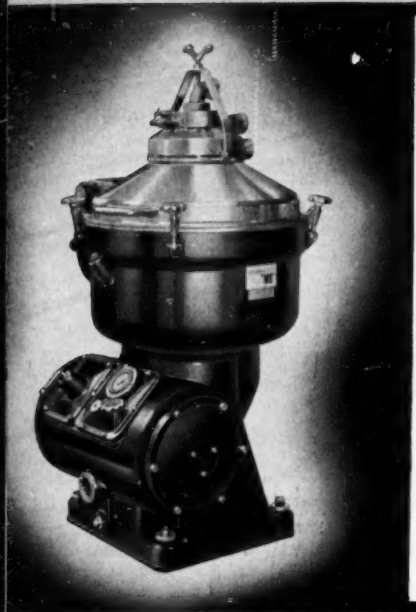
St.Regis PAPER COMPANY

150 EAST 42nd STREET, NEW YORK 17, N.Y.

De Laval tackles process problems



...economically!



New separations made possible by new pressurized centrifuge

Example #1 – highly volatile, inflammable liquid is to be centrifugally separated from water

Example #2 – a foamy, viscous product is to be clarified

Example #3 – a gummy product is to be separated in the purest state possible from the reaction mixture

All of these would be routine problems for the new De Laval SRG-214 Hermetic centrifuge. Capable of operating at pressures up to 125 psi (and higher where necessary), it will process flammable liquids, keep air strictly out of a clarification or separation operation. Resinous, rubbery or waxy reaction products can be separated in their *fluid* state without exposure to air or loss of volatile fluids. Volatile materials can be processed at temperatures otherwise impractical because of vapor problems.

The SRG-214 is a disc-type constant-efficiency centrifuge and is available in corrosion-resistant stainless steel design. Special inlet and outlet seals permit its use under pressure. As a separator, the SRG-214 gives highly efficient separation of immiscible liquids. Ample bowl space for sediment accumulation permits its use as a clarifier as well. Capacities go to 5,000 gals. per hr.

Don't guess. Let us pre-test your separation problem in our own full-scale pilot plant—and provide useful operating data. Write us.

For Further Information Write To Dept. C-6

DE LAVAL

THE DE LAVAL SEPARATOR COMPANY
Poughkeepsie, New York
5724 N. Pulaski, Chicago 46, Illinois

DE LAVAL PACIFIC COMPANY, Dept.
201 E. Millbrae Avenue, Millbrae, Calif.

CENTRIFUGES
PLATE HEAT EXCHANGERS
VIBRATING SCREENS
COMPLETE PROCESSES

Water was scarce . . .
and the tubes were clogging up something awful!

The material was a 13,500 lb/hr shellac-soda ash solution which required rapid cooling from 200° to 70° after de-waxing. A shell-and-tube was bogging down the whole operation with frequent clogging. Lack of water also focused attention on cooling efficiency.

A single section De Laval P-12 Plate Heat Exchanger did the job using less of the 60° cooling water than product stream! The 10° differential indicates the transfer efficiency. Cleaning became a quick and easy operation because the stainless steel plates opened in a moment. The illustration shows how compact this De Laval P-12 Plate Heat Exchanger is.

In another application, the heating of a latex solution caused coagulation that made the use of tube and shell type units impractical. Here the stream was over 250,000 lbs/hr and a two-section De Laval P-15 Plate Heat Exchanger handled the heating requirements easily and offered a practical and inexpensive solution to the clean-up problem.

De Laval offers the widest range of plate heat exchangers available. Our experience can help you.

THE HEAT EXCHANGER'S HEAT EXCHANGER

"Master your craft and you become known, for example, as 'the ballplayer's ballplayer' or 'the comedian's comedian.' There's a rumor (we're spreading it!) that De Laval Plate Heat Exchangers are the . . . you guessed it! Because of their remarkable heat transfer efficiency, extreme compactness and ease of operation and maintenance, our plate heat exchangers are judged to be in a top rank by themselves. Two typical installations where they solved difficult problems are discussed here."

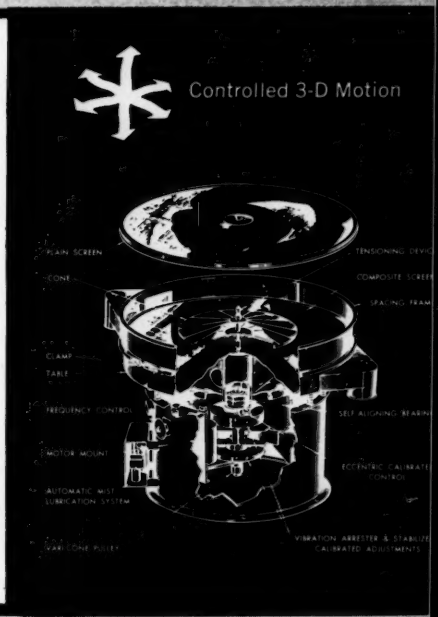
Fred Wheelwright, Industrial Sales Manager

This vibrating screen shook up a pound of inquiries

Anyone using a screen separator is looking for a better one—it seems. Anyway, after the recent Chemical Show, we had on hand almost a pound of inquiry cards voluntarily filled out by bonafide prospects for our Syncro-Matic Screen Classifiers. It was a popular attraction, indeed.

Lookers became prospects when they found that our Syncro-Matic offered a full range of *three-dimensional* controlled motion ranging from gentle classification to turbulent sifting. The frequency is controlled by turning a knob, and the eccentricity control is calibrated for accurate pre-setting. Direct mechanical linkage *assures* a constant classifying action that, unlike gyratory types, does not dampen with heavy loading. Available screens, plain or composite, run the full range of commercial meshes and materials, and you can operate with one, two, or three decks. The base is practically vibrationless and operation is exceptionally quiet.

Soft foodstuffs, abrasive crystals, dry granules, liquids or slurries—all can be handled with excellent through-put and classifying efficiency. Write for details.

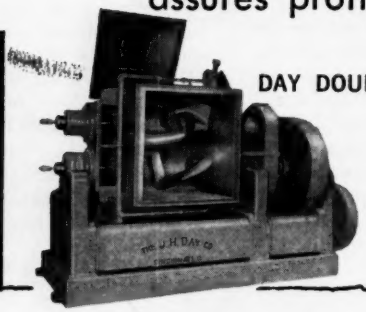


For your processing needs...

advanced DAY equipment

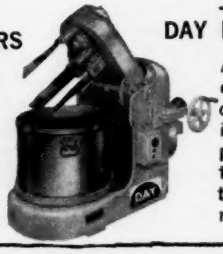
assures profitable performance!

for Mixing



DAY DOUBLE ARM MIXERS

Can't be beat for heavy-duty mixing of viscous fluids and semi-solids. Many types and capacities.



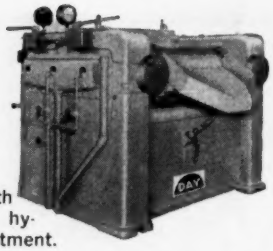
DAY PONY MIXERS

Are the peak of design for all change-can mixing of liquids, pastes, granulations. Single and twin motion models.

for Milling

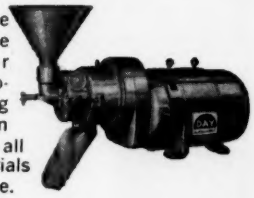
DAY 3-ROLL MILLS

Unsurpassed for fine dispersions of paints, inks, plastisols, ointments and many other heavy pastes and similar materials. Production and laboratory models with screw-type or advanced hydraulic roll pressure adjustment.

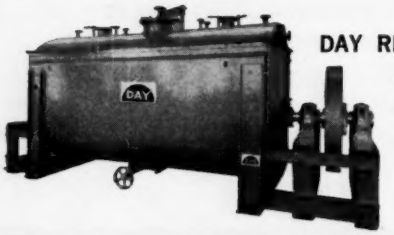


DAY HY-R-SPEED MILLS

They are the choice of the industry for grinding, homogenizing and blending, in one operation, all types of materials flowing or paste.

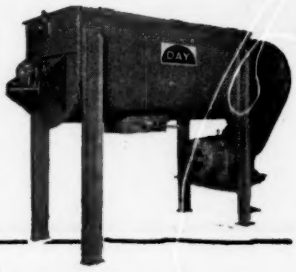


for Blending



DAY RIBBON BLENDERS

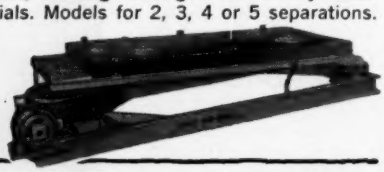
Produce perfect mixing of powders, pastes and liquids. The line is complete —light, medium, and heavy-duty designs.



for Sifting

DAY RO-BALL SIFTERS

With super-active ball cleaners, insure fast, thorough sifting of wet or dry materials. Models for 2, 3, 4 or 5 separations.



USE THE DAY CUSTOMER SERVICE LABORATORY

Our completely equipped laboratory, and staff of skilled technicians, are at your service to help you determine the best method of processing your product. This complete service is available without obligation.

CONSULT WITH DAY ON YOUR PROCESSING REQUIREMENTS

Follow the lead of other major chemical processors and specify DAY equipment—accepted the world over for efficient, economical, dependable service. There is a DAY design that will meet your exact requirements for mixing, milling, blending and sifting operations. For detailed information on DAY equipment, call in a J. H. Day Company field engineer.

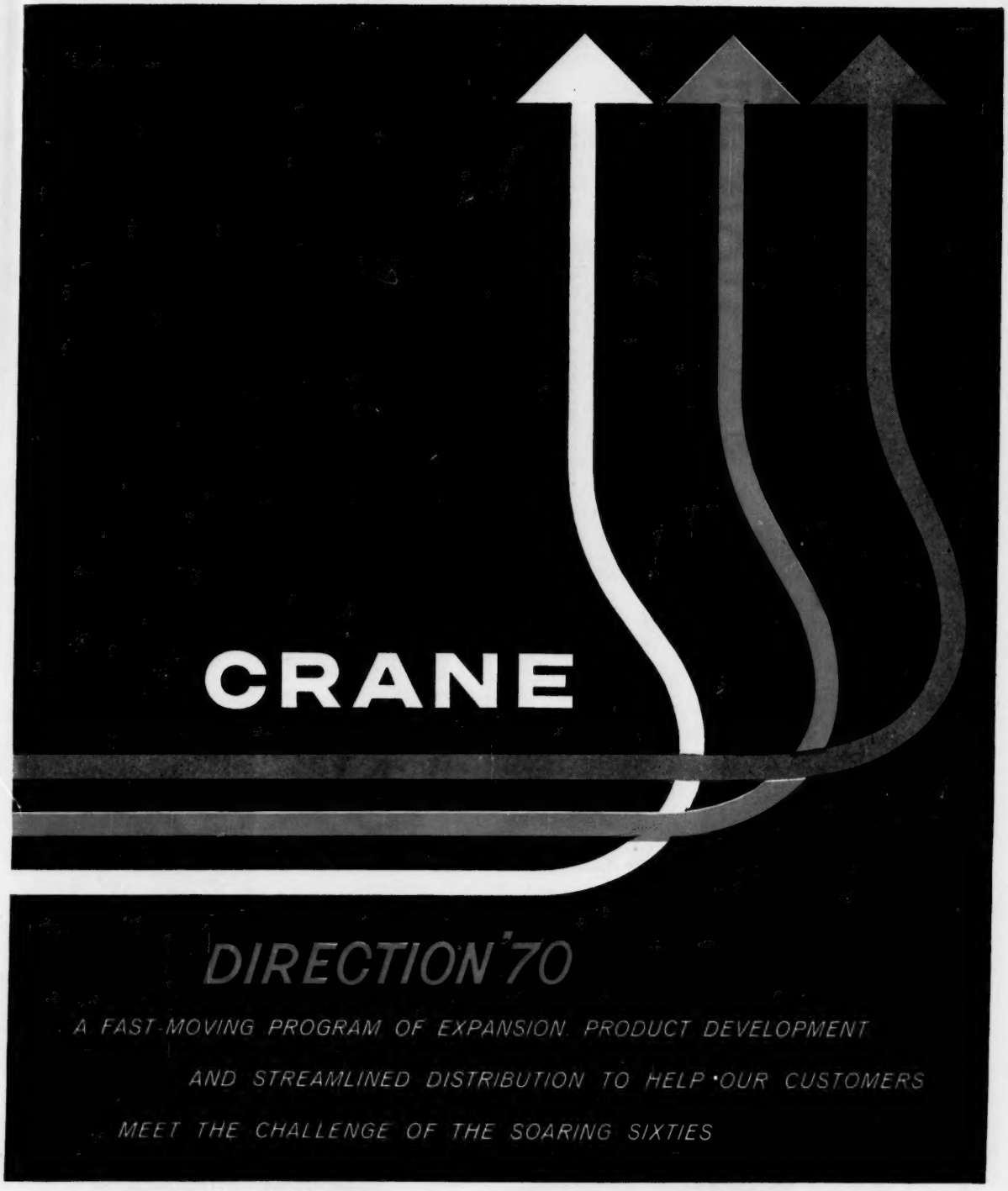
See our catalog in Chemical Engineering Catalog.

The J. H. DAY Co.

Division of The Cleveland Automatic Machine Co.

Manufacturers of Quality Mixing, Blending, Sifting, Milling Equipment since 1887

4926 Beech Street, Cincinnati 12, Ohio

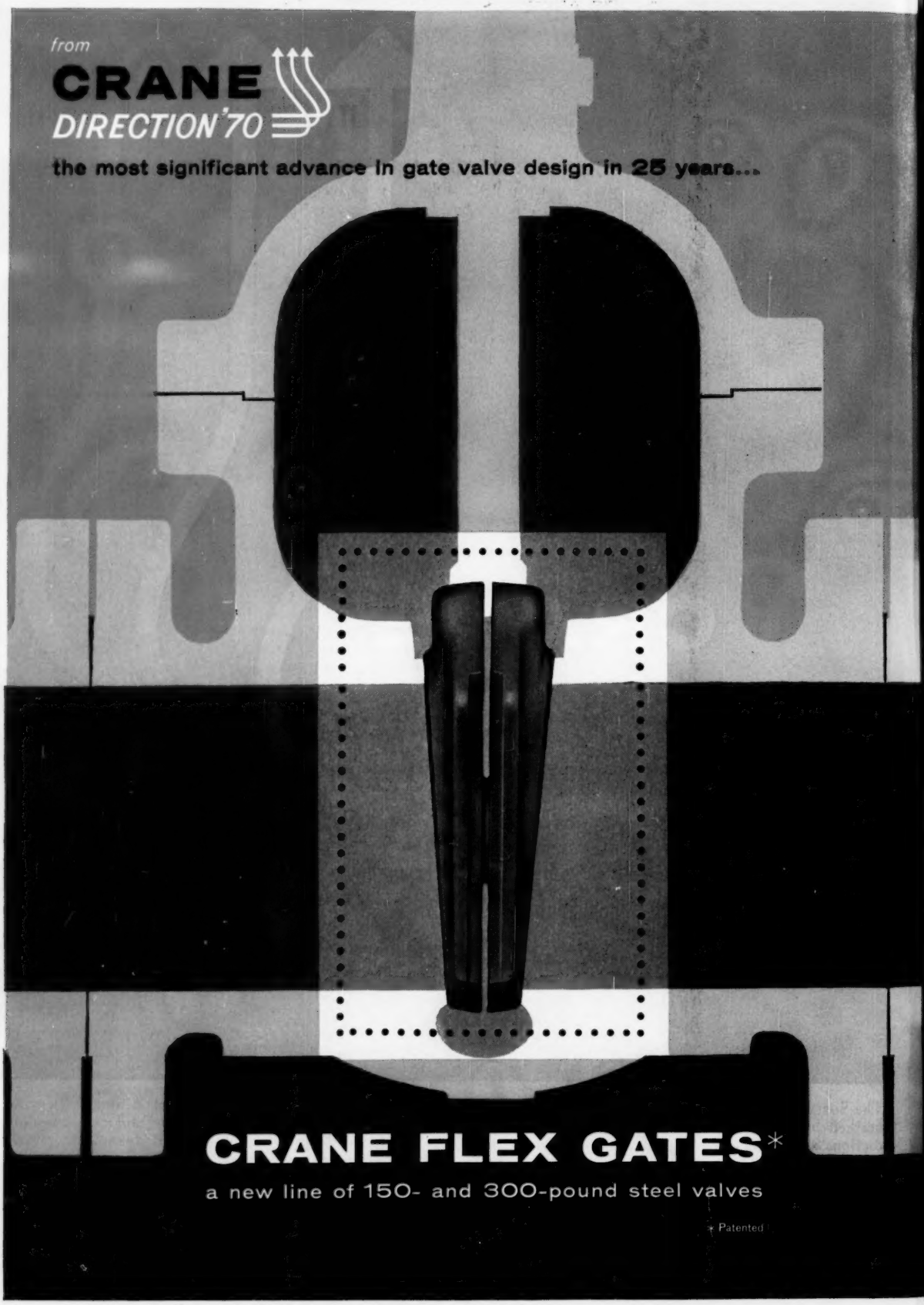

CRANE
DIRECTION '70
A FAST-MOVING PROGRAM OF EXPANSION, PRODUCT DEVELOPMENT
AND STREAMLINED DISTRIBUTION TO HELP OUR CUSTOMERS
MEET THE CHALLENGE OF THE SOARING SIXTIES

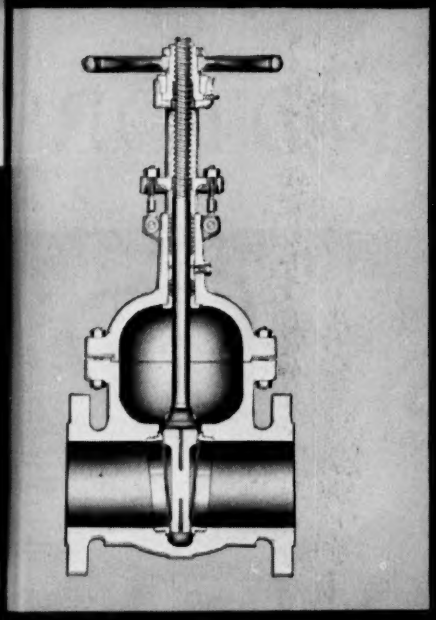
The Soaring Sixties have begun. This is the decade to be marked by accelerated industrial growth. By 1970, predictions are that . . .

- machinery production will double
- petroleum production will increase 4% to 5% each year
- chemicals are to double their present output at the current compound growth rate
- food processing will rise nearly 40%, paper and allied industries will expand about 60%

Total industrial production is estimated to rise some 60% in the next ten years. Looking at it another way, the prospective *increase* in manufacturing and mining is almost as large as the total output of just 12 years ago.

Crane announces Direction '70 . . . new products to help industry meet the challenge of the Soaring Sixties. These are products to improve quality control. These are products to increase production. These are products to help you control your costs. On the following pages is the first . . . the most significant Gate Valve improvement in 25 years. It's the first announcement of many you'll be seeing from Crane in Direction '70.


from
CRANE
DIRECTION '70
the most significant advance in gate valve design in 25 years...
CRANE FLEX GATES*
a new line of 150- and 300-pound steel valves
* Patented



Instead of being made with a solid disc, new Crane Flex Gates have separate disc faces, connected by the spool-like unit you see in the cross section. This joins the two seating faces, yet provides flexibility for the faces to seat tightly with independent action.

FLEXIBILITY PROVIDES THESE BENEFITS

BECAUSE THEY'RE FLEXIBLE, new Crane Flex Gates seat with less torque.

BECAUSE THEY'RE FLEXIBLE, new Crane Flex Gates unseat with less torque . . . will not stick closed even in high temperature service.

BECAUSE THEY'RE FLEXIBLE, minor deflection of seating faces due to pipe strains does not affect tightness of Crane Flex Gates.

BECAUSE THEY'RE FLEXIBLE, new Crane Flex Gates are tight on inlet seat and outlet seat over a wide range of pressures.

BECAUSE THEY'RE FLEXIBLE, new Crane Flex Gates can be used singly in some services where two conventional gate valves are frequently specified. You can save substantially on piping costs. And they have been exhaustively field tested.

BECAUSE THEY'RE FLEXIBLE, new Crane Flex Gates can be serviced—body seat rings replaced or seating faces refinished—quickly without painstaking accuracy. Slightly off-taper seats do not affect tightness or operating ease.

BECAUSE THEY'RE FLEXIBLE, new Crane Flex Gates will easily outperform any conventional solid wedge disc valve you now use. *And there's no increase in price.*

BECAUSE THEY'RE MADE BY CRANE, these new Flex Gates are completely dependable. You can use them with complete confidence on steam, water, gas, oil or oil vapor service. Stem and disc seating faces are Crane Exelloy. Shoulder-type body seat rings are Exelloy or Crane No. 49 Nickel Alloy. Sizes 12 inch and smaller; 150- and 300-pound pressure classes.

• • • • •

Ask your nearby Crane Distributor for full information on Flex Gates—and for data whenever you work with the products Crane makes. He has the newest in information *and* products. Crane Co., Industrial Products Group, 4100 South Kedzie Avenue, Chicago 32, Illinois.

CRANE®

VALVES • ELECTRONIC CONTROLS • PIPING
PLUMBING • HEATING • AIR CONDITIONING

THE MAN & THE MOTORS

Mr. Westinghouse* and the Life-Line A motor brought 56,940 hours' continuous service in highly corrosive atmosphere to Allied Chemical's General Chemical Division

When General Chemical called in their Westinghouse sales engineer back in 1953, they had a serious drive problem. An electric motor was required for 24-hour service in an atmosphere containing hydrogen chloride, sulphur dioxide and sulphur trioxide. Ambient conditions varied from 70° to 100°F.

A Westinghouse Life-Line "A" Type TEFC motor was selected to power a screw conveyer that feeds raw material at the rate of seven tons every 24 hours, 365 days per year, from storage hoppers. A motor breakdown would result in a two-hour shutdown of the equipment it serves.

After more than 6½ years of 'round-the-clock operation, this Westinghouse Life-Line "A" motor is still giving trouble-free service under very severe operating conditions. Such a record indicates many more years of outstanding service.

Mr. Westinghouse is well equipped to step in and help you solve *your* drive problems . . . just as he did at General Chemical Corporation.

**Tom G. Broussard, Westinghouse Sales Engineer in Philadelphia*

RS FROM WESTINGHOUSE

Life-Line A motors and Mr. Westinghouse† team up to bring nonstop, 24-hour operation to sulphuric acid manufacturing for Rumford Chemical Works

Because of the damage caused to the windings of other motors by the highly corrosive atmosphere of sulphuric acid, Rumford Chemical had to rewind an average of two motors a year. Further, any shutdown for repairs not only stopped the process, but released an unbearable nuisance odor into surrounding residential neighborhoods.

The plant engineer of Rumford Chemical says: "In the 10 years we have been using Westinghouse Life-Line motors, we have never once stopped the process because of a faulty motor. Now we never have to rewind our motors because spilled acid can't reach the innards, nor do we have to worry about acid-contaminated lubricating oil or grease because the Westinghouse motors are prelubricated."

†*W. C. Russell, Providence, R. I., office*

Call in The Man from Westinghouse when you need help with your electrical drive or related control requirements. He's well equipped to supply motors from fractional hp to hundreds of "horses." With his experience in drive problems, backed by the industry's best research and development facilities, he'll show you how to save money . . . whether it's a shelf item or a custom-engineered job. For additional information write: Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pennsylvania.

J-22157

YOU CAN BE SURE...IF IT'S Westinghouse

TUNE IN WESTINGHOUSE-CBS TV-RADIO COVERAGE, PRESIDENTIAL CONVENTIONS, JULY 10-29

SERIES 40 GOBBLES UP EXTRA HEAVY CONDENSATE LOADS

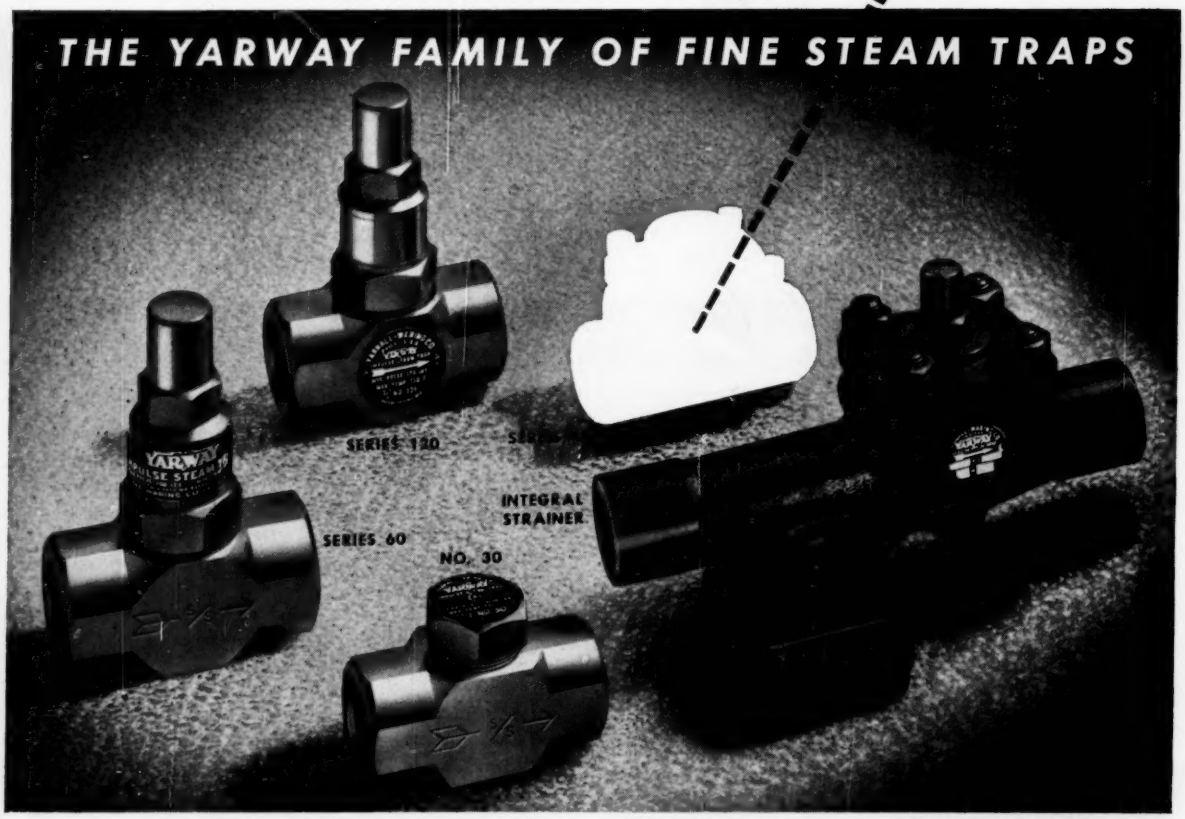
This "thirsty" Yarway Impulse Steam Trap gives you all the well-known Yarway advantages like *quick heat-up, even temperatures, small size, good for all pressures, non-freezing*—PLUS the added feature of *huge capacity.*

For example, at 100 psig the ¾" size will handle 5600 lbs/hr; the 2½" size, 62,000 lbs/hr.

Specify the Yarway Series 40 Trap for applications on large autoclaves, cooking kettles, heat exchangers, heating coils and other places where loads are heavy.

Buy the Yarway Series 40 from your nearby Industrial Distributor—more than 270 stock and sell the Yarway line. Over 1,250,000 Yarway Impulse Steam Traps already sold.

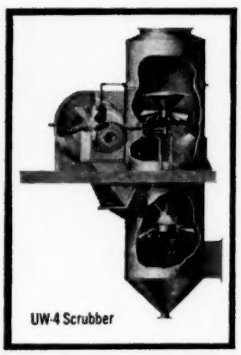
YARNALL-WARING COMPANY
137 Mermaid Ave., Philadelphia 18, Pa.



SERIES 60—normal needs, pressures to 400 psi, 6 sizes. **SERIES 120**—normal needs, pressures to 600 psi, 6 sizes. **SERIES 40**—for extra heavy loads, 5 sizes. **NO. 30**—for extra light loads (½" only). **INTEGRAL STRAINER**—highest pressures and marine use, 6 sizes.

YARWAY | *impulse® steam traps*

THE SWIRL, SWAT AND SCRUB METHOD OF CONTROLLING DUST



There's an old song that goes something like this: "It Ain't What You Do; It's The Way That You Do It." This holds true for wet dust collection and one of the most effective ways of **doing** it is dynamically with a Ducon UW-4 Scrubber.

The centrifugal forces and water action inside this scrubber, combining with the unique and effective dynamic action of the high velocity fan in the second stage of operation, literally swirl, swat and scrub all the dust particles from the gas stream.

The UW-4 Scrubber is a most effective unit for separation of extremely fine dusts and abrasive materials and is ideally suited for heavy dust loads and high temperature applications.

Send for Bulletin 7460.

The name in Dust Control

THE DUCON COMPANY, Inc.

147 EAST SECOND STREET • MINEOLA, L. I., NEW YORK

CYCLONES • CENTRIFUGAL WASH COLLECTORS • TUBULAR CLOTH FILTERS • DUST VALVES

Canadian Branch:

THE DUCON COMPANY, of CANADA, Ltd., 1133 Pomit St., BURLINGTON, ONTARIO, CANADA

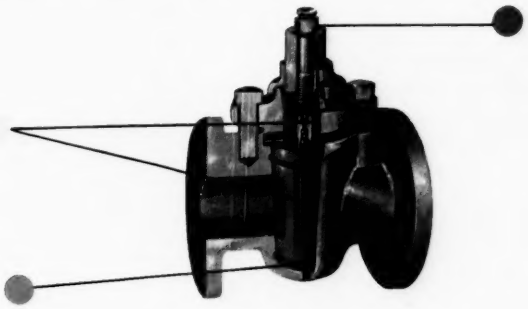
The Chinese had water distribution systems centuries ago. "Pipes" were sections of bamboo continuously spouting water. While date or inventor is not certain, one of the earliest valves was made by boring a hole in a plug and fitting it into holes cut in the bamboo pipe.

he stopped a trickle of water

. . . and his idea helped give you a better valve

One of the first known valves, a plug cock invented by the Chinese, had two inherent advantages never equalled by any other type of valve: *simplicity in construction and operation.* It controlled flow with only one moving part, the rotary plug.

To these basic advantages, the modern Rockwell-Nordstrom valve adds a third: *pressurized lubrication.* Pressurized lubrication totally seals the valve against leakage and maintains an instantly renewable seat. It also reduces wear and assures easy operation. And because there are only three basic parts – plug, body, and cover – you get longer life and lower cost–"The fewer the parts, the fewer the repairs." For more advantages of the Rockwell-Nordstrom valve, see the illustration below.



RUGGED DESIGN PLUS LUBRICATION SAVES MONEY

- Lubricant quickly, easily injected through Rockwell fitting.
- Lubricant travels through Sealdport® system to create powerful seals against leakage and prevent metal-to-metal wear between plug and body . . . note seats never exposed to the line.
- Lubricant hydraulically jacks plug minutely from seat for instant quarter-turn operation.

Rockwell-Nordstrom is the original and world's most complete line of lubricated plug valves. Available in sizes from ½" to 36" and pressures to 15,000 lb. For additional information, see your supplier or write: Rockwell Manufacturing Company, Pittsburgh 8, Pennsylvania. Canadian Valve Licensee: Peacock Brothers Limited. If you live outside the USA, write: Rockwell International S.A., Geneva, Switzerland.

Lubrication Makes The Difference

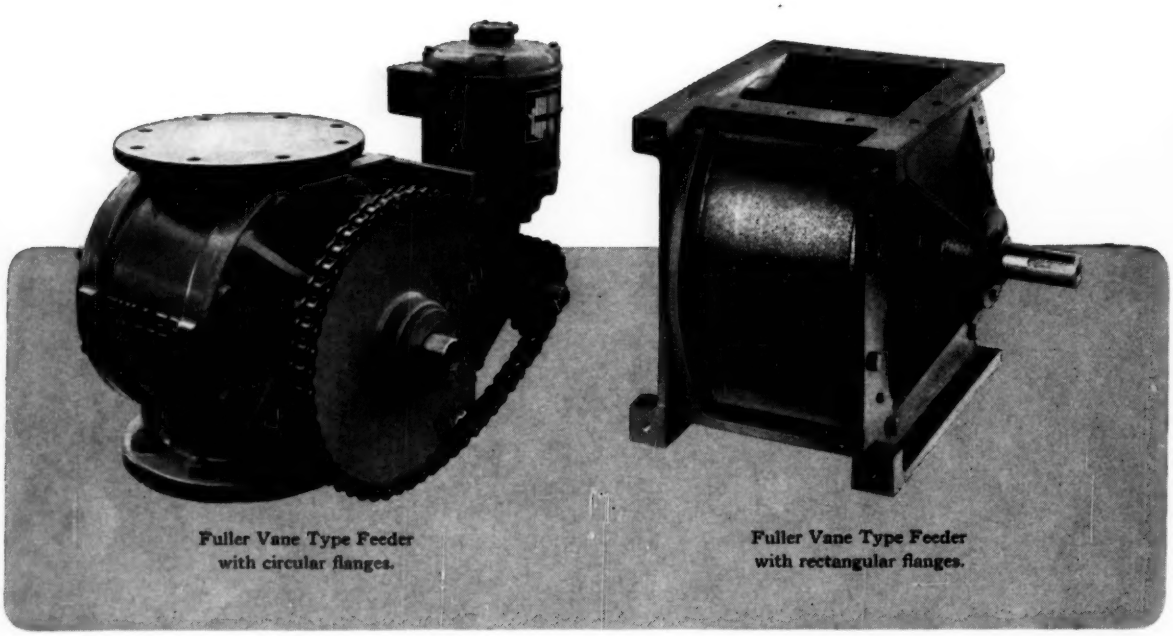
ROCKWELL-Nordstrom VALVES

another fine product by

ROCKWELL

Fuller Feeders
Keep Conveyors Flowing Freely

. . . whether the load is a few pounds a minute or many tons an hour



Fuller Vane Type Feeder with circular flanges.

Fuller Vane Type Feeder with rectangular flanges.

Fuller Vane Type Feeders assure you of dependable handling of dry, pulverized and granular materials. They're available in capacity ranges to meet all normal plant requirements, and are built with circular or rectangular outlets. Check these Fuller cost-saving features . . .

Extra-rugged construction. Heavy, cast iron body walls and headplates add rigidity, longer life. Stainless or other metals can be used where sanitary or corrosion requirements demand their use.

Sealed bearings are equipped with Alemite fittings for ease of lubrication and long life. Abrasive particles can't enter, maintenance is cut.

Make effective air locks. Fuller Vane Type Feeders can be used as air locks for pressure differentials up to 3½ lbs.

Stuffing boxes and ball bearings for vacuum, low-pressure and general applications.

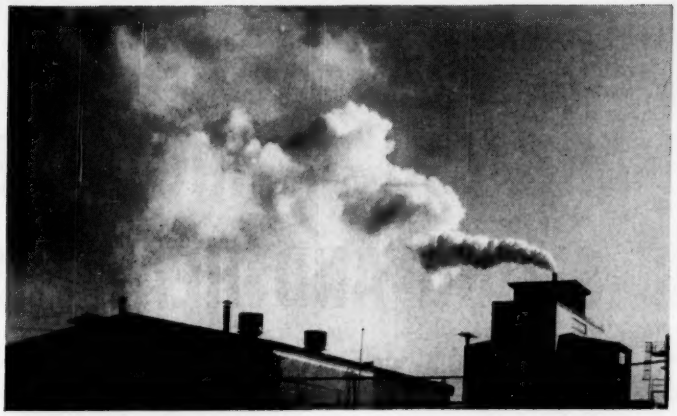
And, where extreme volumetric accuracy without pulsation is needed, there's a line of Fuller Roll Type Feeders. For full details on Fuller Feeders write for Bulletin.

See Chemical Engineering Catalog for details and specifications . 1306 F-20

FULLER COMPANY GENERAL AMERICAN TRADE MARK

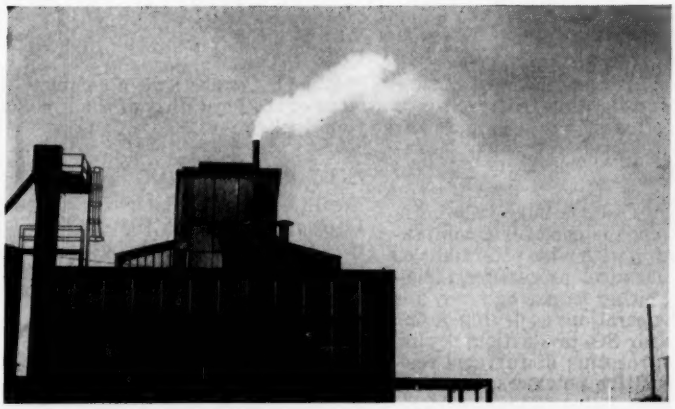
Fuller . . . pioneers in harnessing AIR

FULLER COMPANY
134 Bridge St., Catasauqua, Pa.
Subsidiary of General American Transportation Corporation
Offices in Principal Cities Throughout the World



Before scrubber was installed —visible cloud is composed largely of water with about 0.5% sulfur trioxide

THE CHEMICO VENTURI SCRUBBER MAKES THE BIG DIFFERENCE



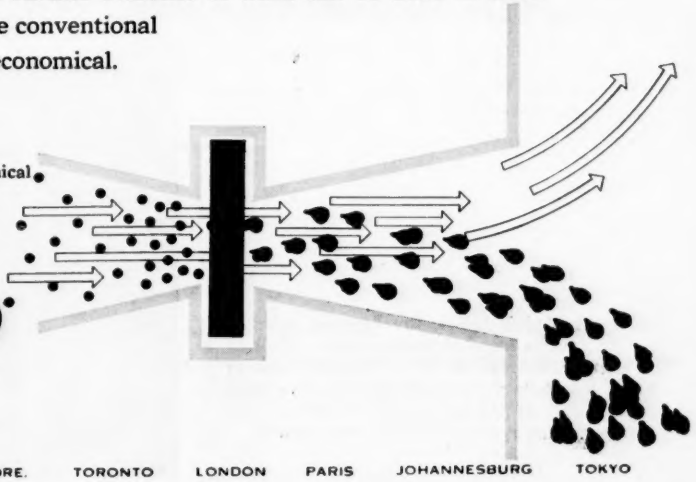
After scrubber was installed— water vapor has diminished considerably, sulfur trioxide content is practically nothing

With sulfur trioxide fumes being vented to the air in a thick vapor fog, Ansul Chemical faced an air pollution problem common to many chemical producers. They were willing and anxious to comply with community requests for pollution control, but they were unable to find a scrubber which could rid the stack of both the water vapor and the SO_3 as well.

While virtually any scrubbing device was capable of removing the water vapor, only the Venturi scrubber was effective in removing the acid fumes. By removing all but the last traces of SO_3 the Venturi scrubber gave further evidence of what can be done to solve really tough gas cleaning problems where conventional cleaning devices prove ineffective or uneconomical.

FULL DETAILS AVAILABLE

For your copy of a brochure giving complete data on Chemico Venturi gas scrubbers, or for technical assistance on a specific problem, write to Chemico at the address below.



CHEMICO

CHEMICAL CONSTRUCTION CORPORATION
Gas Scrubber Division
525 West 43rd Street, New York 36, New York

CHICAGO DALLAS HOUSTON PORTLAND, ORE. TORONTO LONDON PARIS JOHANNESBURG TOKYO

ARE YOU PAYING A PENALTY DRYING, SIZING AND HEAT-TREATING

Here's how Dorr-Oliver can help you plan for profitable PLANT MODERNIZATION with the FluoSolids System

If you're looking for improved methods of drying and heat treatment as one step towards profitable plant modernization, you'll want to investigate the broad opportunities offered by today's most versatile, rapidly advancing technique – the Dorrco FluoSolids System.

Based on the principle of solids fluidization, the FluoSolids System answers the need for a continuous, high capacity operation with wide potentialities for application in the chemical processing industries. Typical examples, either in use or ready for application, include such operations as drying of fine coal, roasting of pyrites for SO_2 production, drying of chemical precipitates, roasting of furfural residues, drying of heat-sensitive polymers, low temperature calcination of phosphates and hydrochloric acid and sodium sulphate production by the Hargreaves Process.

The FluoSolids System is essentially simple, adaptable to precise temperature control, economical in equipment and space required and low in operating and maintenance costs. It is the logical system for any process where intimate contact is required between gases and solids from ¾" to 325 mesh.

To interested plant engineers Dorr-Oliver offers a complete program of evaluation and practical application assistance. Features include:

LABORATORY EVALUATION

At Dorr-Oliver's research and development center, Westport, Connecticut, a complete analysis can be made of the feasibility of the FluoSolids System for your application.

PILOT PLANT TESTING

Facilities are available for thorough pilot plant testing, from which the results of full scale commercial application can be accurately predicted. In many cases, test set-ups can be made to simulate a complete processing operation.

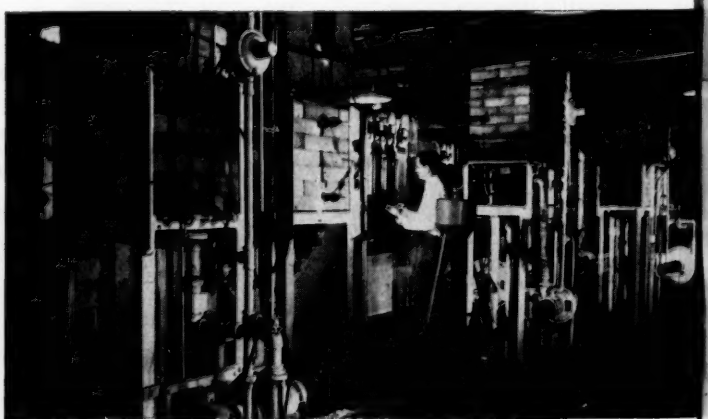
PLANT ENGINEERING

Dorr-Oliver engineers will cooperate in planning a complete installation to fit into your existing production line or work with you in designing a new processing operation. The experience gained in planning hundreds of successful installations is at your service.

FLEXIBLE FINANCING

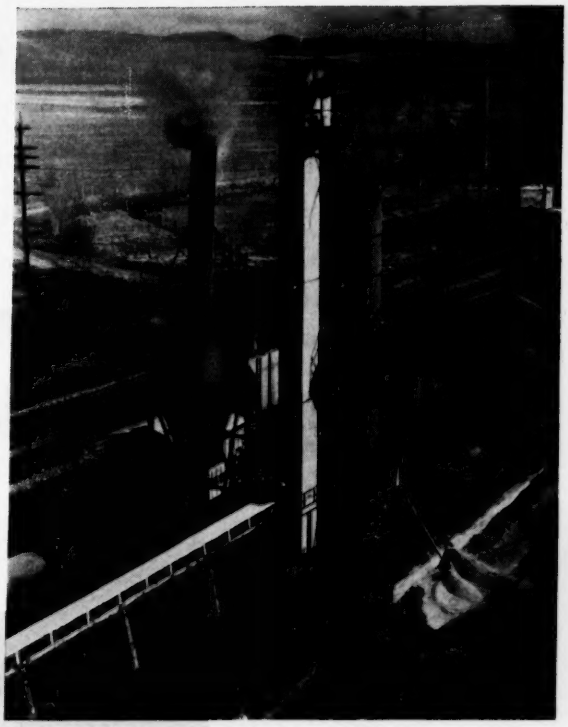
Dorr-Oliver will explore with you or your management appropriate financing plans to suit your particular requirements. These may range from outright purchase to the possibility of special leasing arrangements with consequent savings in expenditure of working capital.

An inquiry costs nothing. For full information, write to Dorr-Oliver Incorporated, Stamford, Conn.

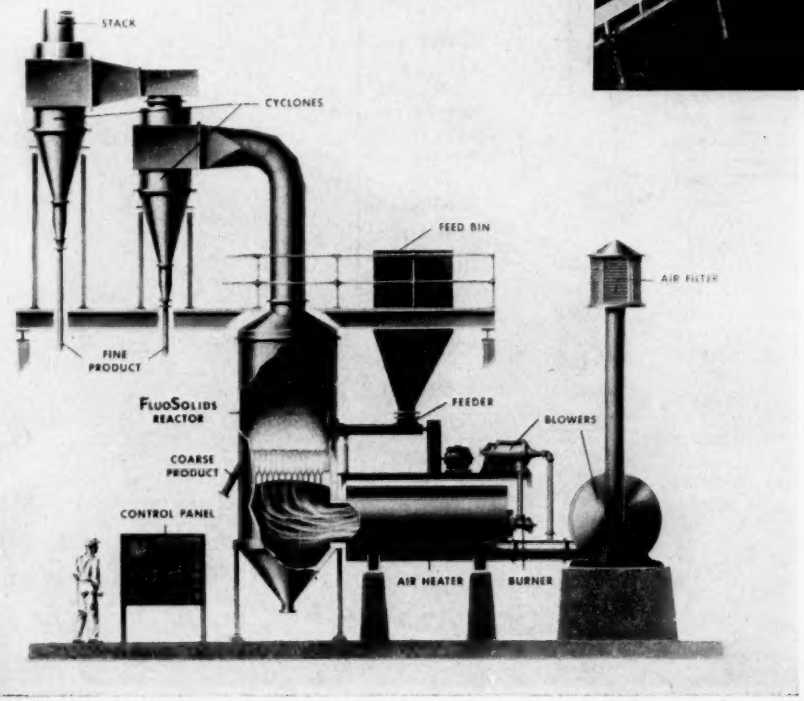


Six FluoSolids Laboratory Reactors, with 4" I.D. reactor tubes of stainless steel or silicon carbide, installed at D-O's Westport research center. Photo shows lower sections of reactors and part of insulating brick chimneys, with gas heating systems and instrument panels.

FOR OBSOLETE METHODS?



Large Portable Pilot Plant can be disassembled and shipped to any location for on-the-spot operation in the final stages of certain specialized testing and development programs involving one or two stage operation.



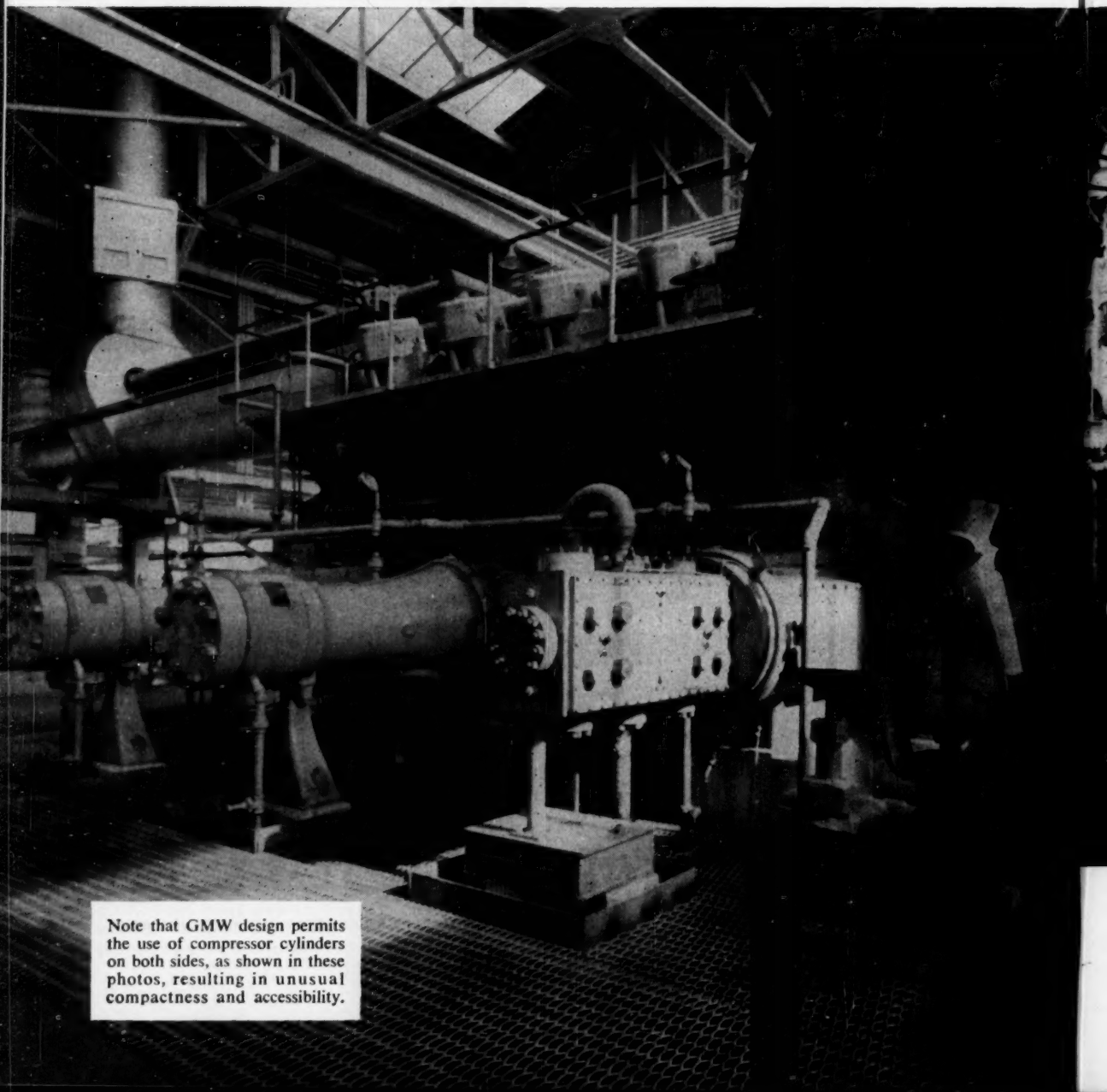
Cutaway illustration of a full scale FluoSolids System for drying.

DORR-OLIVER

WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT

Report from American Cyanamid, Fortier Plant...

How Cooper-Bessemer gas engine boost synthesis gas for ammonia



Note that GMW design permits the use of compressor cylinders on both sides, as shown in these photos, resulting in unusual compactness and accessibility.

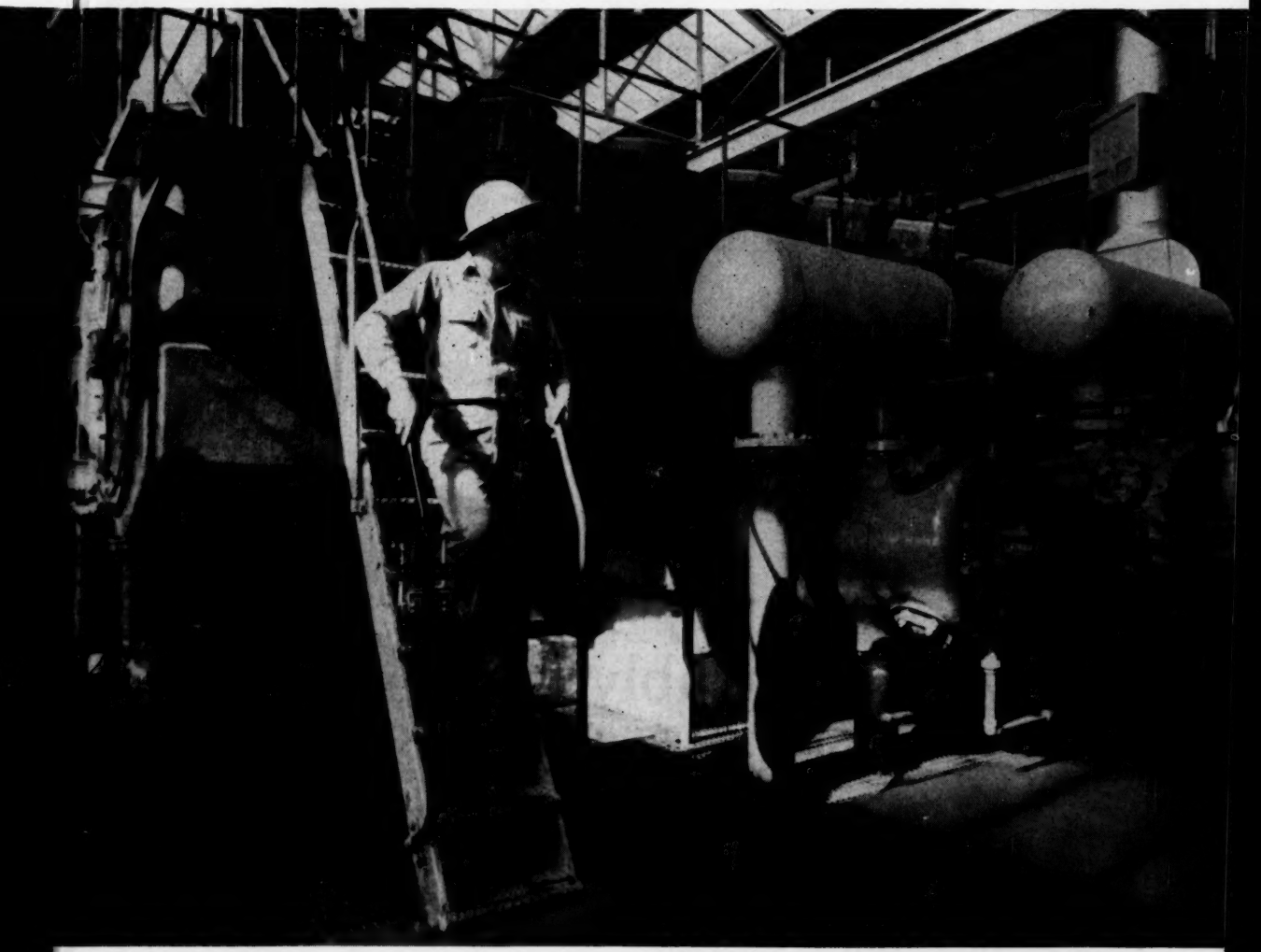
ine compressors
nia o 5000 psi

These photos show both sides of one of the two Cooper-Bessemer 2500 hp GMW gas engine compressors at the Fortier Plant of American Cyanamid Company, Avondale, Louisiana. In the production of anhydrous ammonia, these 4-stage units compress 6000 cfm of synthesis gas from 60 psi to a discharge of 5000 psi. The left-hand view shows the high pressure cylinders; that on the right shows the low pressure side. The four stages of compression from 60 psi are (1) to 225 psi, (2) to 670 psi, (3) to 1500 psi, (4) to 5000 psi.

The two units have been operating since 1954, 24 hours a day, 340 days a year.

The anhydrous ammonia produced at the Fortier Plant is used by American Cyanamid in the manufacture of Acrylonitrile and is sold to fertilizer plants and other chemical companies.

Find out how Cooper-Bessemer can help *you* plan compression and power facilities. Write for copy of bulletin, "Cooper-Bessemer Equipment for Chemical Plants."



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The Rotor Tool Company... Cleveland

Cooper Bessemer

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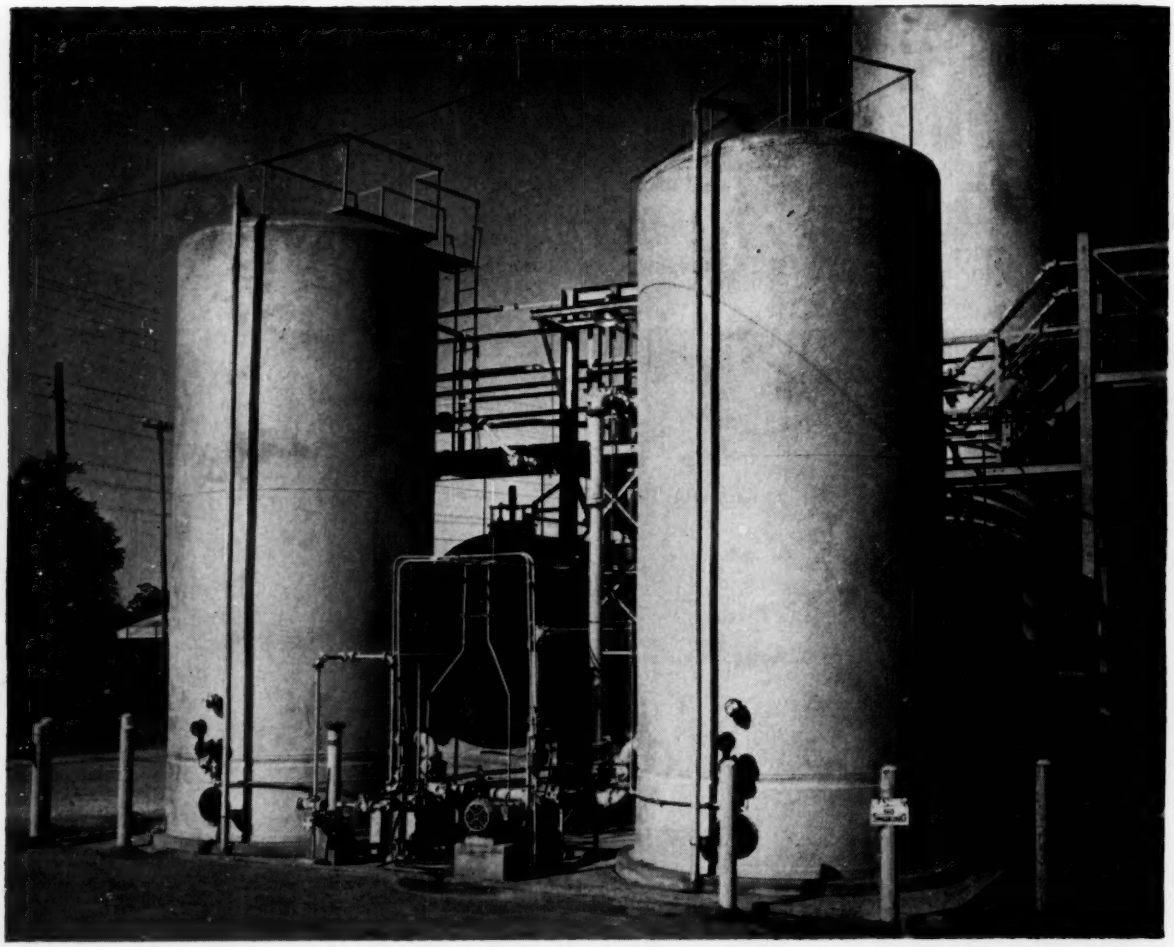
ENGINES: GAS • DIESEL • GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL
ENGINE, TURBINE OR MOTOR DRIVEN

FLUIDICS* AT WORK



Glasteel takes the bite out of corrosive chlorine dioxide at Scott Paper Company's mill in Mobile, Alabama.

How to profitably end corrosion in every phase of ClO_2 generation

If you examined these tanks for dissolving and storing sodium chlorate, you'd find no evidence of corrosion at the constantly shifting liquid-air interface.

Combination of materials is the reason. These are Pfaudler® Glasteel tanks—*steel* outside for strength, *glass* inside for corrosion resistance. And there is no rust contamination of the chlorate, which can cause troublesome "puffs."

Glasteel towers and pumps. These tanks plus towers, pumps and ClO_2 storage tanks are part of the chlorine dioxide system at Scott Paper Company in Mobile, Alabama. In operation for over 15 months now, there has been no evidence of corrosive attack in any part of the system where Glasteel has been used.

Economy the key. You will also find Glasteel equipment in 38 other progressive pulp mills. And, whether the Solvay or Olin Mathieson process is used, the reports are still the same: Pfaudler Glasteel turns out to be the *most economical* equipment available, in terms of cost, maintenance and service life.

Complete systems. With this experience and our Project Engineering service, Pfaudler offers you or your engineering firm complete plant design, procurement and installation for ClO_2 generating systems.

More information. For details, or answers to specific questions, please write to the address shown on the facing page.

How to test the value of Glasteel polymerizers

Consider three important factors — purity of the polymer, amount of downtime, and initial cost. Then, look at what you can expect from Pfaudler Glasteel polymerizers.

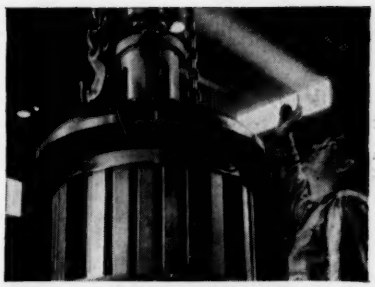
Product purity. Glasteel will not contaminate or discolor materials you use in making synthetic resins. Nor will it act as a catalyst to set off undesired side reactions.

Naturally, you also get Glasteel's unmatched acid-alkali corrosion resistance, so you can project a long service life for this equipment.

Reduced downtime. Glasteel has an abrasion-resistant, smooth surface — smoother than the most highly polished metals. So even sticky substances don't adhere readily. What little does, you wash away quickly between batches, using the Pfaudler glassed Spray Rinse Valve. Thus you can expect to put through more product per day.

Lower cost. Glasteel costs less—significantly so—than the alloys you probably would consider in order to protect your product's purity. Just how much you can save will be apparent after you have had a chance to discuss your needs with one of our representatives.

Complete specifications and operating characteristics are covered in Bulletin 932. We'll be happy to send you a copy.



Does a WIPED FILM evaporator fit your process?

Yes, if you evaporate products that are
(1) heat sensitive, or
(2) highly viscous, or
(3) low in thermal conductivity.

What makes the Pfaudler Wiped Film Evaporator so well suited is the *mechanically wiped* evaporating surface.

It works like this: Centrifugal force of an internal rotor (pictured at left) holds four free-floating wipers in contact with the evaporator wall. These wipers spread your product out over the entire evaporating surface in a *thin, uniform* film. Slots in each wiper prevent product "curl" forward of the wipers and accelerate product movement down the wall.

Since the heated wall is kept completely wet, you are sure of maximum heat transfer — a very important consideration with viscous and heat-sensitive materials, or those with low thermal conductivity.

Test, anyone? In our Test Center we maintain a 4-square-foot Wiped Film Evaporator for product evaluation studies.

Production units offer 4 to more than 100 square feet of evaporating areas. (That's a 50-square-foot one being assembled in the picture.)

We'd be happy to send you detailed specifications or provide further information about the test program.

Four easy steps put F-C Glasteel Pipe* in your plant

Here's a corrosion-resistant, high-integrity lined pipe that's literally as easy as 1-2-3-4 to install.

Just take a section of Pfaudler F-C Glasteel Pipe (the F-C means "field cut") and cut to the length you want on a standard, dry abrasive cutoff wheel.

Next, thread—just as you see in the picture.

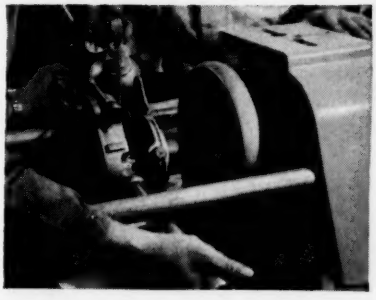
Third step: Fire-polish with a small, portable furnace. (You can get one from Pfaudler at modest cost that you will recover through the savings from a few installations.)

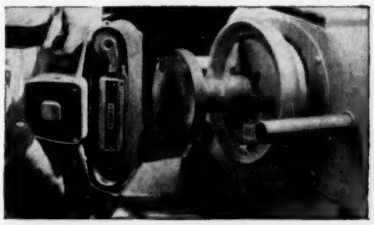
Then, thread on flange and belt sand to assure that gasket seat is flat and the flange connection seal-tight.

For complete details, ask for Bulletin 989.

Address all inquiries to our Pfaudler Division, Dept. **CE-60,** Rochester 3, N. Y.

*Patent applied for





FLUIDICS AROUND THE WORLD

Pfaudler Permutit is a world-wide company with manufacturing plants in: Germany, Great Britain, Canada, Mexico and Japan, as well as four plants in the U. S. A.

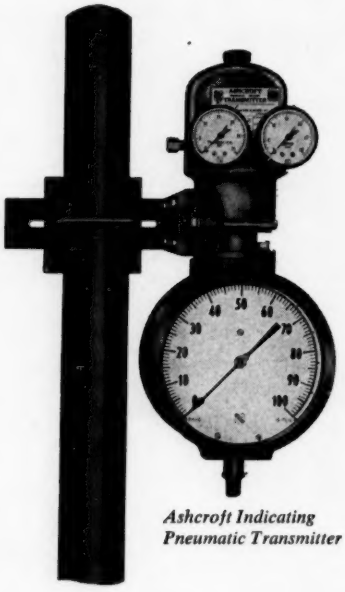
*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

PFAUDLER PERMUTIT INC.

Specialists in FLUIDICS . . . the science of fluid processes

signal

ASHCROFT PNEUMATIC TRANSMITTERS give you a true primary and transmitted signal for indication or control



Ashcroft Indicating Pneumatic Transmitter

action

Now—detect with precision accuracy the slightest change in primary pressure or temperature. Transmit this signal quickly to your indicators or controllers. Ashcroft Pneumatic Transmitters achieve these results for you at the lowest initial and operating costs.

Full-range, solid-front indicating and totally accessible nonindicating transmitters eliminate the need for costly high pressure lines, yet permit complete monitoring of process conditions in remote areas.

Narrow-span Ashcroft Transmitters are expressly designed with highest sensitivity and repeatability for the most accurate primary signal feed to controllers. You get better control and purer, lower-cost final products.

Only in Ashcroft Pneumatic Transmitters can you get the wide choice of Ashcroft Duragauge Bourdon tubes or American mercury or gas-actuated systems for sensing pressure or temperature conditions. You also get a time-proven, obstruction-proof, force-balance, nonbleed relay for economical, maintenance-free 3-15 psi or 3-27 psi signal transmission.

Write for factful Bulletins 360 and 361 or ask your nearby Ashcroft Distributor to help you select the right transmitters and receiver gauges for your specific requirements.

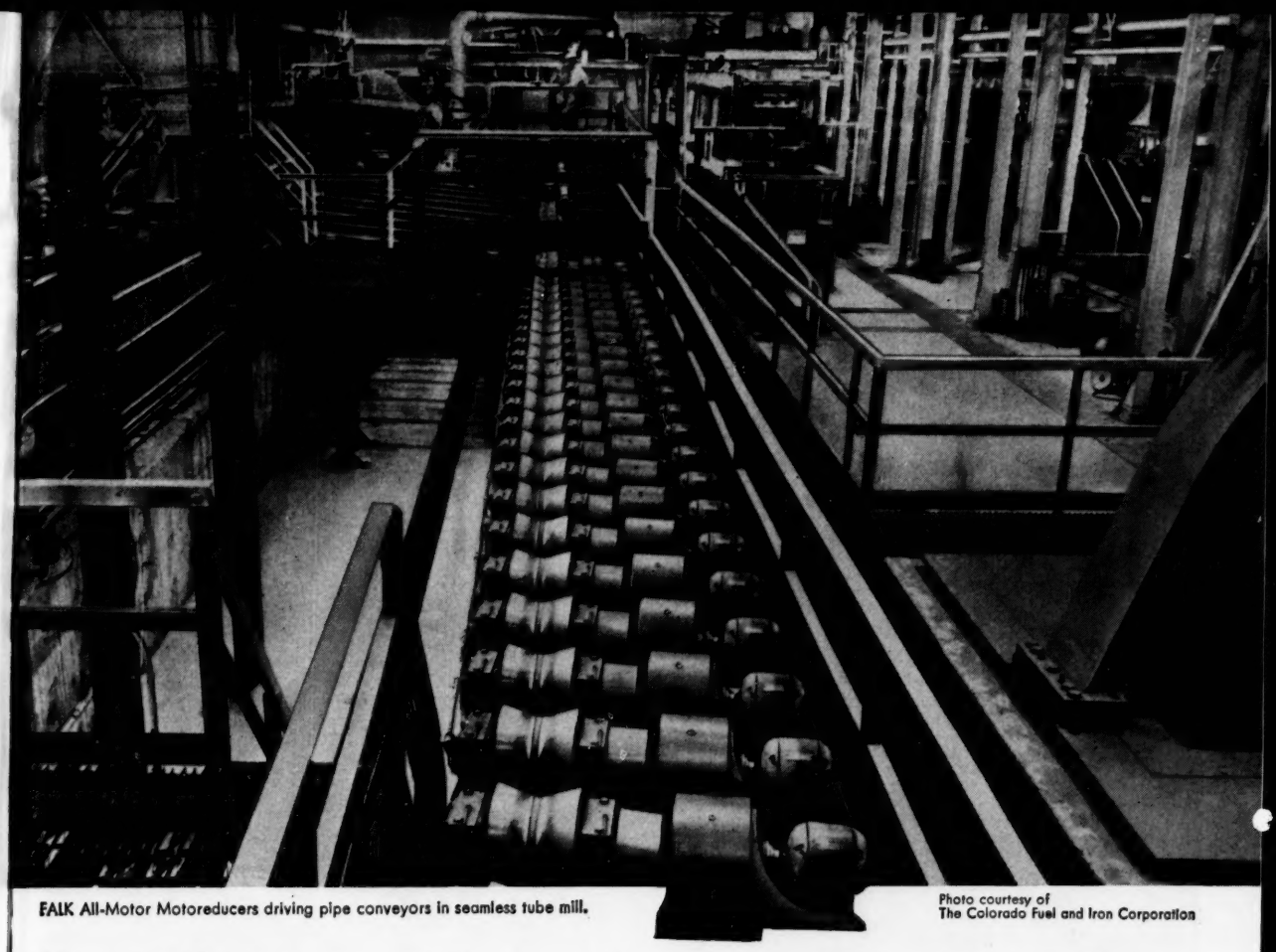
MANNING MAXWELL & MOORE INC. M&M TRADE MARK

ASHCROFT PNEUMATIC TRANSMITTERS

A product of

MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario



FALK All-Motor Motoreducers driving pipe conveyors in seamless tube mill.

Photo courtesy of
The Colorado Fuel and Iron Corporation

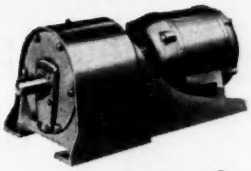
You get these "extras" when you buy FALK *all-steel* Motoreducers

1. **Freedom from damaged housings.** The exclusive FALK *all-steel* construction gives full protection from cracked housings or torn-off feet...plus twice the ability of cast iron to maintain vital alignment.
2. **12-15% reserve load-carrying capacity** in the gears, by AGMA standards. The extra-depth, high pressure angle helical gears are another FALK exclusive ...they assure better operation and longer gear life.
3. **Highest known gear efficiency**—98½% per gear train under full load! This means maximum productive work for your power dollar.
4. **Longer service life**...advanced FALK design makes it possible to machine both bores for each shaft assembly at one time, thus eliminating possible accumulation of tolerances that occurs when individually machined parts are assembled. The result—better alignment of revolving elements that permits units to transmit rated capacity longer.
5. **Standard units to fit your needs.** Integral and All-Motor® Motoreducers are available in horizontal, vertical and right angle types...a type for every use.

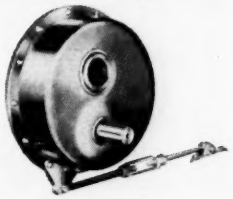
Units are available up to 75 hp; output speeds from 780 rpm down to 1.2 rpm. Prompt delivery from factory, warehouse or distributor stocks.
Ask your FALK Representative or Authorized FALK Distributor for *Bulletin 3100.*

THE FALK CORPORATION, MILWAUKEE 1, WIS.
MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS
Representatives and Distributors in most principal cities

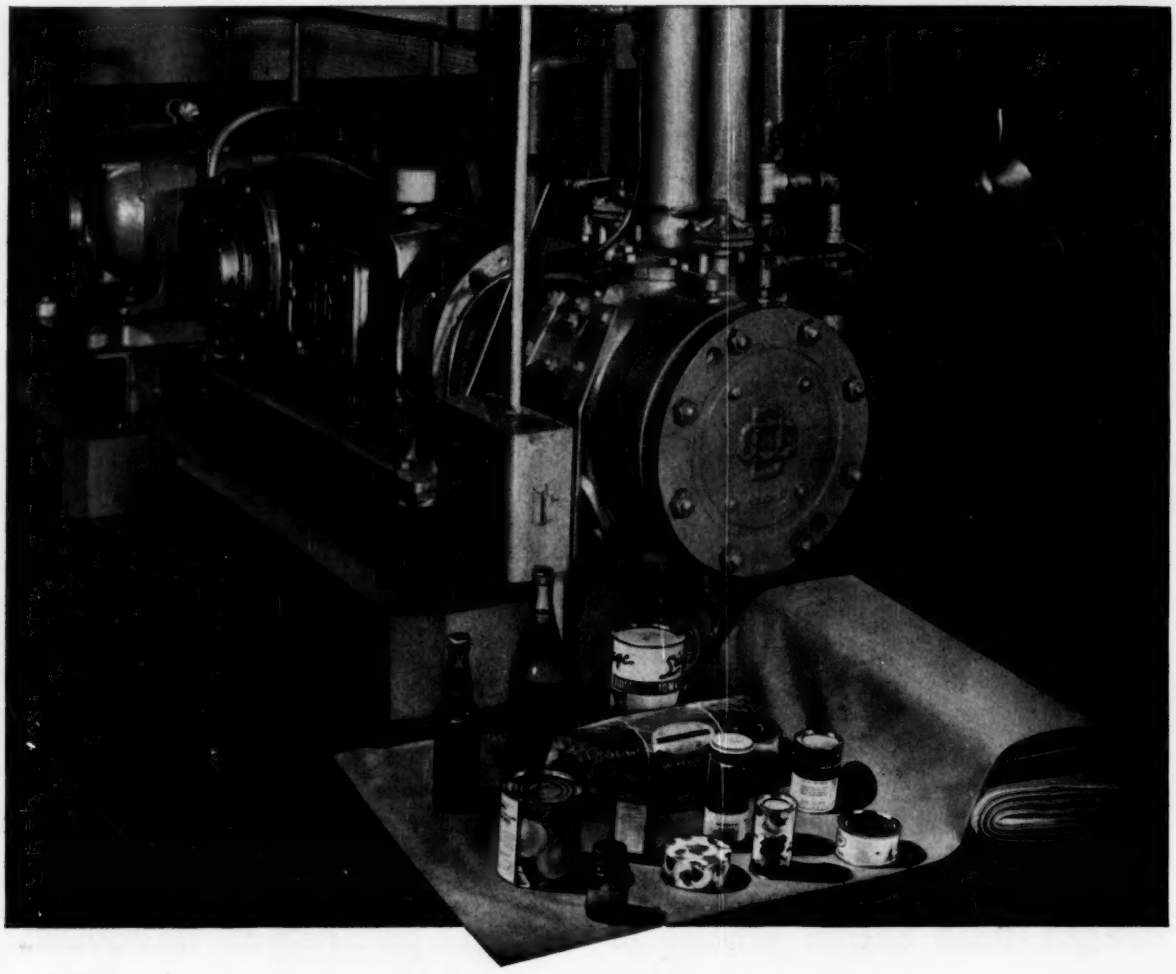
FALK
...a good name
in industry



THE FALK ALL-MOTOR® MOTOREDUCER
the original All-Motor unit
(Shown) Horizontal concentric model. Also available in right angle and vertical types.



THE ALL-STEEL FALK® SHAFT MOUNTED DRIVE
Proved best for the countless industrial applications where a reducing unit mounting directly on shaft of the driven machine is indicated.
Units from 1/2 to 50 hp. Ratios —4:1, 14:1 or 24:1. Torque capacity up to 41,000 lb-in (in standard units). Prompt shipment from stock. For details, ask for *Bulletin 7100.*

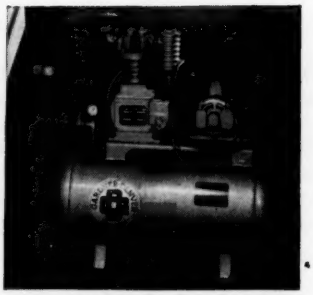


Air helped produce these products...

pure, oil-free air from GARDNER-DENVER

This Gardner-Denver Model CRX has enabled many an industry to utilize low-cost compressed air power without penalty to their products. The CRX produces pure, oil-free air without special filters. It provides versatile "go" power to help speed production, cut costs, and keep air-actuated equipment moving.

If a trace of oil in your air line is *too much*, ask your Gardner-Denver Compressor Specialist about the CRX. Sizes range from 100 to 1400 cfm.



For a small, oil-free compressor, the Model CACB is hard to beat. Supplies 4 to 5 cfm . . . discharge pressures 40 to 100 psi.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

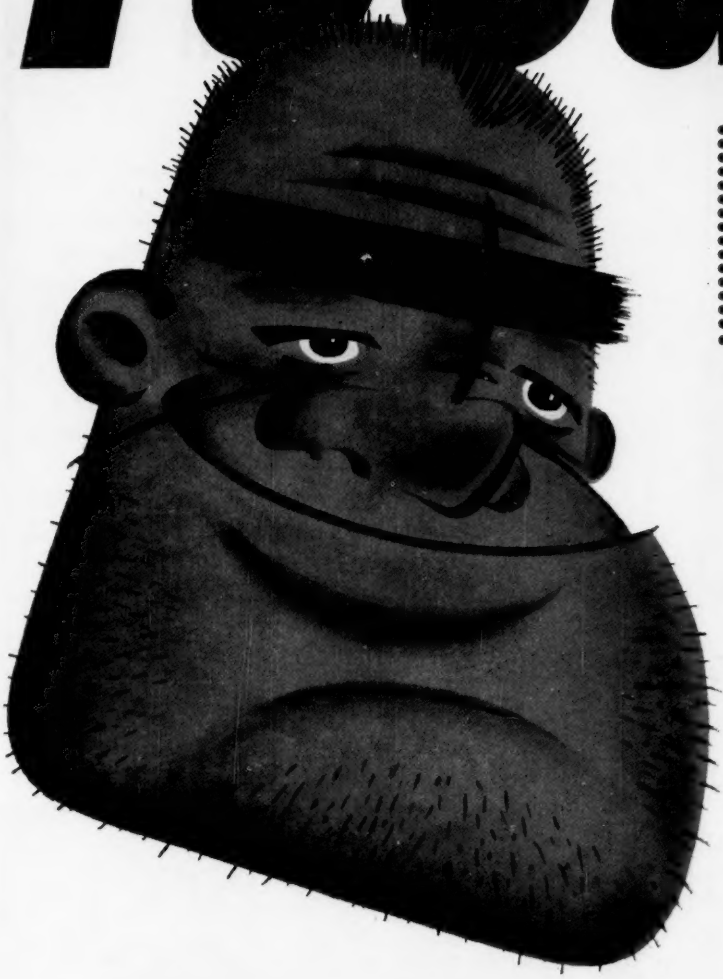
GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Ave., Toronto 16, Ontario

JUST PLAIN

TOUGH!

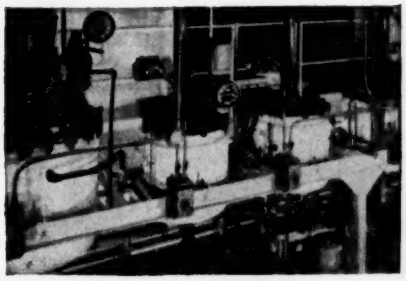


Rust-Oleum
HEAVY-DUTY
CHEMICAL RESISTANT
Coatings

For use where the going is TOUGHEST

This modern, new Rust-Oleum development is best described by three old-fashioned words—*JUST PLAIN TOUGH!* These Heavy-Duty Chemical Resistant Coatings are specially formulated for use where the going is toughest—on unpainted metal, wood, or masonry surfaces—on conveyors, equipment, machinery, pipes, structural steel, tank exteriors, walls and ceilings. Resistant to most acids, alkalis, chemicals, hydraulic fluids, machine coolants, jet fuels, oil, gasoline, aliphatic and aromatic solvents. Equally important—Rust-Oleum Heavy-Duty Chemical Resistant Coatings *really stick to unpainted concrete floors.* Available in practical and pleasing pastel colors!

Your nearby Rust-Oleum Industrial Distributor has complete stocks for prompt delivery. Ask him for complete details, including a free test application, or write us for the facts.



RUST-OLEUM®

Distinctive as your own fingerprint. There are imitations, but only one Rust-Oleum.

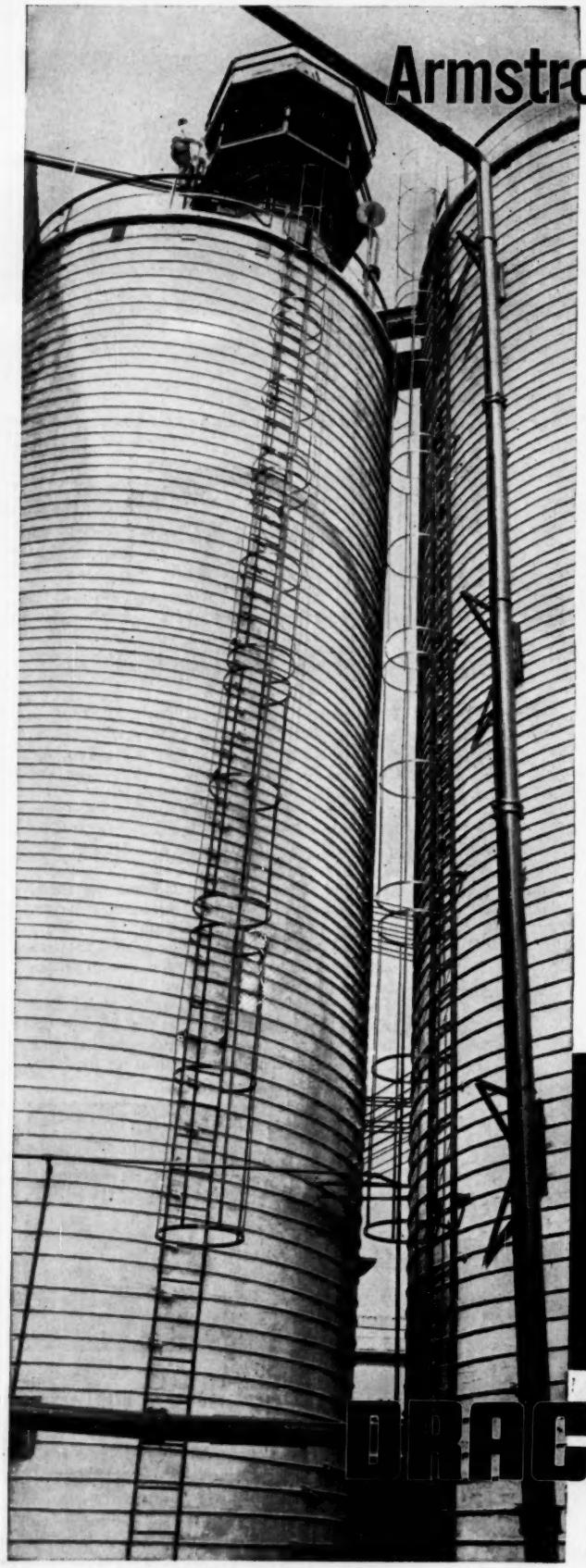
STOPS RUST!®

ATTACH TO YOUR LETTERHEAD

Rust-Oleum Corporation
2514 Oakton St., Evanston, Ill.

☐ Complete details, including actual color charts and applications.

☐ Free test application on my own metal, wood, or masonry surfaces.

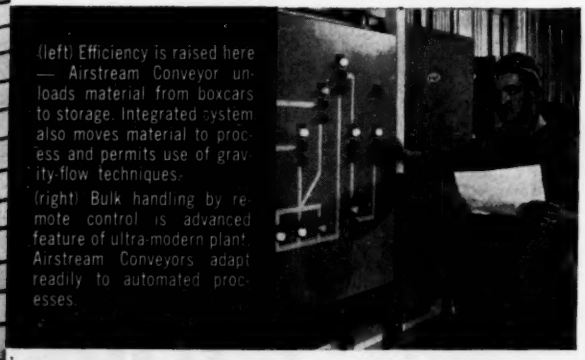


Armstrong Cork Co. goes *"up in the air"* to keep handling costs down

Automatic bulk handling with a Dracco Airstream Conveyor System provides a major assist in maintaining top quality, automated production at one of Armstrong's resilient flooring plants.

This plant is the world's most modern facility for manufacture of asphalt and vinyl-asbestos flooring tile. Airstream Conveying was chosen to furnish low-cost bulk handling in conjunction with other advanced processing techniques. The system unloads filler from boxcars, stores it, then moves it to process with only part time supervision of one man.

This is just one example of how economical air conveying helps industry gain more profits from automation. For full information on how Dracco can upgrade your materials handling, write: Dracco Division of Fuller Company, Harvard Avenue and East 116th Street, Cleveland 5, Ohio.



(left) Efficiency is raised here — Airstream Conveyor unloads material from boxcars to storage. Integrated system also moves material to process and permits use of gravity-flow techniques.

(right) Bulk handling by remote control is advanced feature of ultra-modern plant. Airstream Conveyors adapt readily to automated processes.

DRACCO *airstream* conveyors
dust control equipment

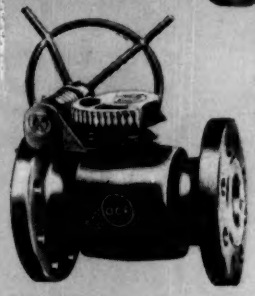
FULLER COMPANY GENERAL

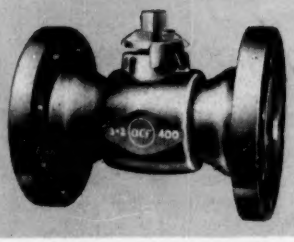
Photographs by the Armstrong Cork Co.

"Install 'em anywhere – no maintenance needed"

PRODUCT OF W-K-M's

Creative Engineering





ACF non-lubricated Ball Valves feature Teflon stem gaskets and seats. There's no lubricant to cause sticking or contamination.

Working Pressures: In carbon steel with ASA ratings of 150 pound and 300 pound, and some sizes in ASA 600 pound; in semi-steel with 200 and 400 pound WOG ratings.

Sizes: ½" through 6". Regular port valves up to 8" x 6".

acf non-lubricated Ball Valves

ACF Ball Valves are not only non-lubricated . . . but designed *throughout* for maintenance-free performance. For example: The ball is suspended between Teflon* seats under compression for leakproof sealing. Seats are protected from the lading flow. And the full bore conduit provides *smooth* flow, with no destructive turbulence . . . no more pressure drop than through an equal length of pipe.

A quick quarter-turn operates this rugged valve. Specify it. You'll get efficient, economical performance. *Available from leading suppliers everywhere.*

* Du Pont Trademark

WRITE FOR CATALOG 1000

W-K-M

DIVISION OF acf INDUSTRIES
INCORPORATED
P. O. BOX 2117, HOUSTON, TEXAS

5922

DOW | INSULATION

Styrofoam insulation on pipes and equipment maintains temperature and humidity for processing blood and pharmaceutical products.

STYROFOAM® prevents condensation . . . helps maintain exact temperatures!

In the production of pharmaceuticals, temperature and humidity are frequently critical . . . and sanitary requirements can't tolerate dripping pipes. That's why Styrofoam* was chosen to insulate pipes, ducts, even blowers in five separate cooling systems in a new Ortho Pharmaceutical Corporation installation at Raritan, New Jersey. Functions of the five systems range from maintaining efficient, low temperatures in cold storage rooms, to keeping one special processing room at exactly 80°F., with only 15% relative humidity.

Because Styrofoam resists penetration of water and water vapor, moisture does not get to the pipes to form an icing condition. This prevents condensation and dripping. In addition, moisture does not destroy the low "K" factor of Styrofoam, thus assuring permanently high insulating efficiency. And Styrofoam cannot rot nor deteriorate–has no food value to support plant or animal life.

The light weight of Styrofoam (only 2.4 ounces per board foot) helps designers by reducing the dead weight load on pipes–and speeds installation.

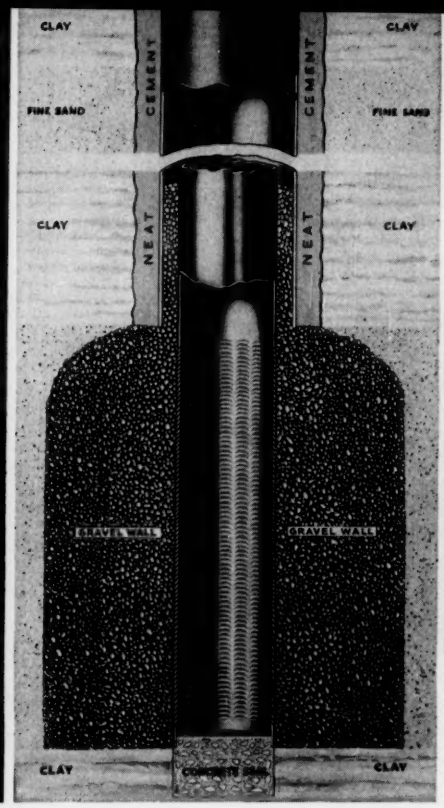
Dow supplies Styrofoam to the expert fabricators listed below, who shape it into standard pipe and vessel coverings and also make segments of special shape and thickness. Check with the nearest fabricator for full information. Or, write THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Merchandising Department 1650AK6-13.

*DOW'S REGISTERED TRADEMARK FOR ITS EXPANDED POLYSTYRENE

Pipe and Vessel Covering Fabricators

DAL-VIR INC., Elkhart, Indiana • FIBROUS GLASS PRODUCTS, INC., Hicksville, L. I., New York • GLO-BRITE, Chicago, Illinois • KENNEDY INDUSTRIES, Los Angeles, California KRAHSCO MANUFACTURING COMPANY, South San Francisco, California • MMM, INCORPORATED, Houston, Texas • ROBINSON INDUSTRIES, Coleman, Michigan • STYRO FABRICATORS, Kansas City, Kansas • STYROFORMICS, INC., Somerville, Mass. • STYROPLASTICS, INCORPORATED, Minneapolis, Minnesota • TUFFLITE PLASTICS, INC., Ballston Spa, New York

THE DOW CHEMICAL COMPANY • MIDLAND, MICHIGAN



WATER WATER WATER

With A Layne Drilled Well Layne knows where the water-bearing formations are located. They have been drilling wells for over 75 years. This experience comes from searching and researching water aquifers. Knowing *where* to drill is half of the success—knowing *how* is the other half. In drilling a straight well experience counts—and you can count on Layne. Layne specializes in water well drilling. To get a good start for a water supply—you need a good well. You get a good, producing well when you specify a Layne drilled well. *Bulletin No. 100*

With A Layne Gravel Wall Well This technique and resulting arrangement of the new 134 Shutter Screen and gravel (shown here) permits the free flow of water into the well and affords the following advantages: larger shutter screen openings, reduced friction, reduced draw down and pumping head—thereby reducing pumping costs, increased specific capacity and more effective retention of native sands. Cemented wells are installed if indicated, and result in greater purity of supply as well as increased life of the well. *Bulletin No. 900*

With A Layne Vertical Turbine Pump Whatever the pumping requirement, there's a Layne pump to meet any pumping conditions. Layne Vertical Turbine Pumps come in a wide range of sizes and capacities, delivering 30 to 20,000 GPM and requiring from 4 to 42 inch well casings. The complete line of Layne Pumps include: Deep Well Vertical Turbine (oil or water lubricated), Short Coupled Vertical Turbine, Propeller, Mixed Flow, Fire Pumps and Volatile Liquids Pumps, Regular and "In-Line" Submersible. *Bulletins No. 200 (oil) 201 (water)*

LAYNE OFFERS COMPLETE WATER SERVICE: Initial surveys • explorations • recommendations • site selection foundation and soil-sampling • well drilling • well casing and screen • pump design, manufacture and installation construction of water systems • maintenance and service • chemical treatment of water wells • water treatment—all backed by Layne Research. Layne services do not replace, but coordinate with the services of consulting, plant and city engineers.

Layne SINCE 1882

WORLD'S LARGEST WATER DEVELOPERS

LAYNE ASSOCIATE COMPANIES THROUGHOUT THE WORLD

Sales Representatives in Major Cities

For safe delivery of pure phosphorus chlorides, Hooker ships in "A" Nickel. 3000-gallon tank made by Niagara Welding and Boiler Works, Inc. to specifications of the 1956 ASME Unfired Pressure Vessel Code, combines high strength with maximum corrosion resistance.

How Nickel keeps corrosive chlorides free from contamination as they roll from plant to market

In providing customers with phosphorus oxychloride and trichloride, Hooker Chemical Corporation sidesteps the whole problem of contamination by shipping in Nickel. For local and high-priority shipments, they use the 3000-gallon "A" Nickel tank truck shown.

"A"* Nickel and its high alloys, such as Monel* nickel-copper alloy, have demonstrated remarkable resistance to chlorides. Nickel and Monel alloy resist general attack, pitting, and chloride ion stress corrosion cracking. Applied stress, welding, crevices, wetting, drying, and vapor phase exposure do not promote stress corrosion cracking or intergranular corrosion in Nickel or Monel alloy.

In neutral and alkaline chlorides, rates of attack seldom go above 0.005 ipy . . . even under adverse temperature, agitation and aeration.

In acid chlorides too, Nickel and its high alloys provide useful corrosion resistance. Especially, when the acid chlorides are those of ammonium and zinc. In this medium, corrosion rates under 0.02 ipy are usual.

The same general relationships hold over a wide range of temperatures from that of refrigeration brines to those of salt evaporators.

With such corrosion resistance, it's easy to see why makers and users alike prefer to process, store and ship color sensitive, corrosive chlorides in "A" Nickel or Monel alloy equipment. Product stays "water-white". Equipment lasts longer.

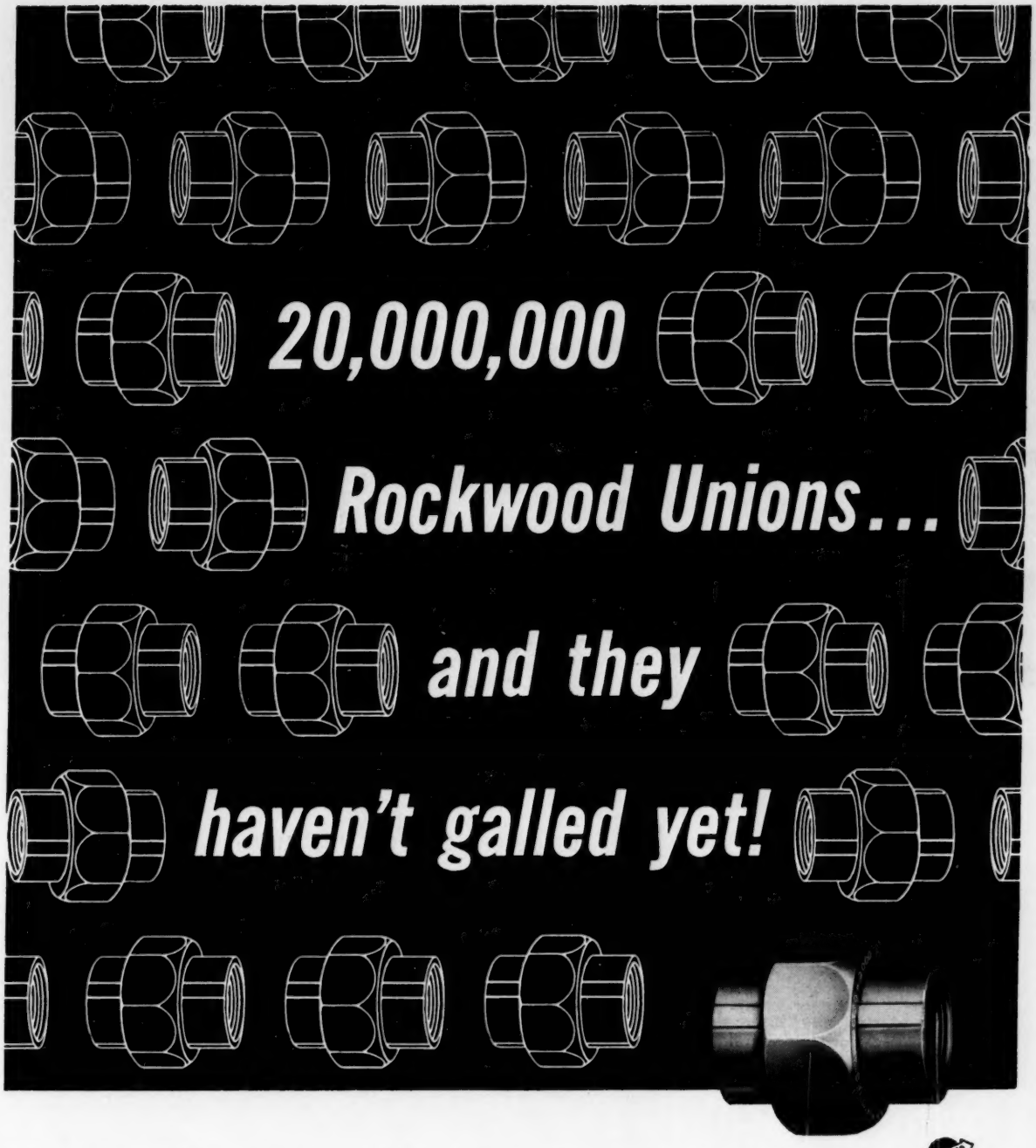
Fabrication of "A" Nickel and its high alloys is no problem. The metals are plentiful and most fabricators are as familiar with them as with steels and procedures for obtaining sound welds are well established.

Which should *you* use? "A" Nickel? Monel alloy? Inconel* alloy? One of the many other high nickel Huntington Alloy Products? We'll be glad to make suggestions based on many thousands of successful applications. Just let us know the conditions.

*Inco trademark

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17, West Virginia

INCO TRADE MARK **ALLOY PRODUCTS**



Only ROCKWOOD Cold Forged Steel Unions have the hardness differential which *assures* fast, easy make-up, a tight seal, and free from galling. Male seat is heat-treated to a hardness substantially higher than that of the female seat. Then both seats are forged in place and double-locked under 100,000 and 400,000-pound pressures. Other outstanding features include: special color-coding for immediate identification, Rockwoodizing which gives all surfaces *positive* protection against corrosion, interchangeable parts. Get complete information now. Write for facts.

ROCKWOOD SPRINKLER COMPANY

Distributors in all principal industrial areas

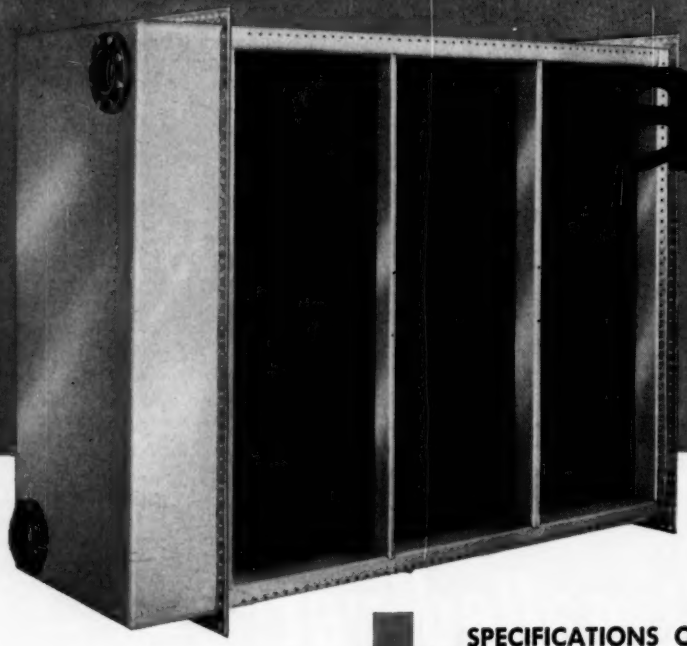
ROCKWOOD SPRINKLER COMPANY
A Division of The Gamewell Company
760 Harlow Street
Worcester 5, Massachusetts

Please send me prices and further information on Rockwood Unions.

Name.....
Title.....
Company.....
City.....*Zone*.....
State.....

Marlo

Liquid/Gas Heat Exchanger



any

APPLICATION, ALLOY, OR SIZE

Write or Phone for Additional Information for Your Application.

SPECIFICATIONS ON THIS UNIT:

MATERIAL: 316 ELC Stainless Steel
Face Dimensions: 60" x 72"
Overall Dimensions: 98" x 68" x 30"

TUBES: 0.035" wall, ⅝" O.D.
Spacing: 1½" center to center, staggered

FINS: 0.010" plate type with die-formed ferrules
Spacing: 8 per inch

SURFACE: Total: 10,650 sq. ft.
Primary: 558 sq. ft.

CASING: Air tight at 60 inches W. G.

OPERATING PRESSURE: 1500 p.s.i.

WEIGHT: 5100 lb. dry

Marlo coil co.

SAINT LOUIS 11, MISSOURI

Quality Air Conditioning and Heat Transfer Equipment Since 1925

ALEMITE BARREL-TO-BEARING LUBRICATION...

prime mover in production!

Plant men who recognize lubrication as an important production tool – not just a maintenance problem – are collecting new dividends in increased production.

They use modern Alemite Barrel-to-Bearing Lubrication . . . years ahead methods that add efficiency and speed up production in all sizes and types of plant operations . . . assure better, lower-cost protection . . . cut downtime, prolong machinery life.

Alemite lubrication equipment includes electric, air or hand-operated equipment . . . everything required for high-pressure lubrication, filling of hydraulic systems, servicing oil reservoirs, lubricating gear housings, and refilling grease guns.

Let an Alemite expert help you with the most efficient lubrication system ever developed. A letter or phone call will bring him to you, at no cost or obligation.

Write for free Alemite catalog today!

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STEWART-WARNER CORPORATION

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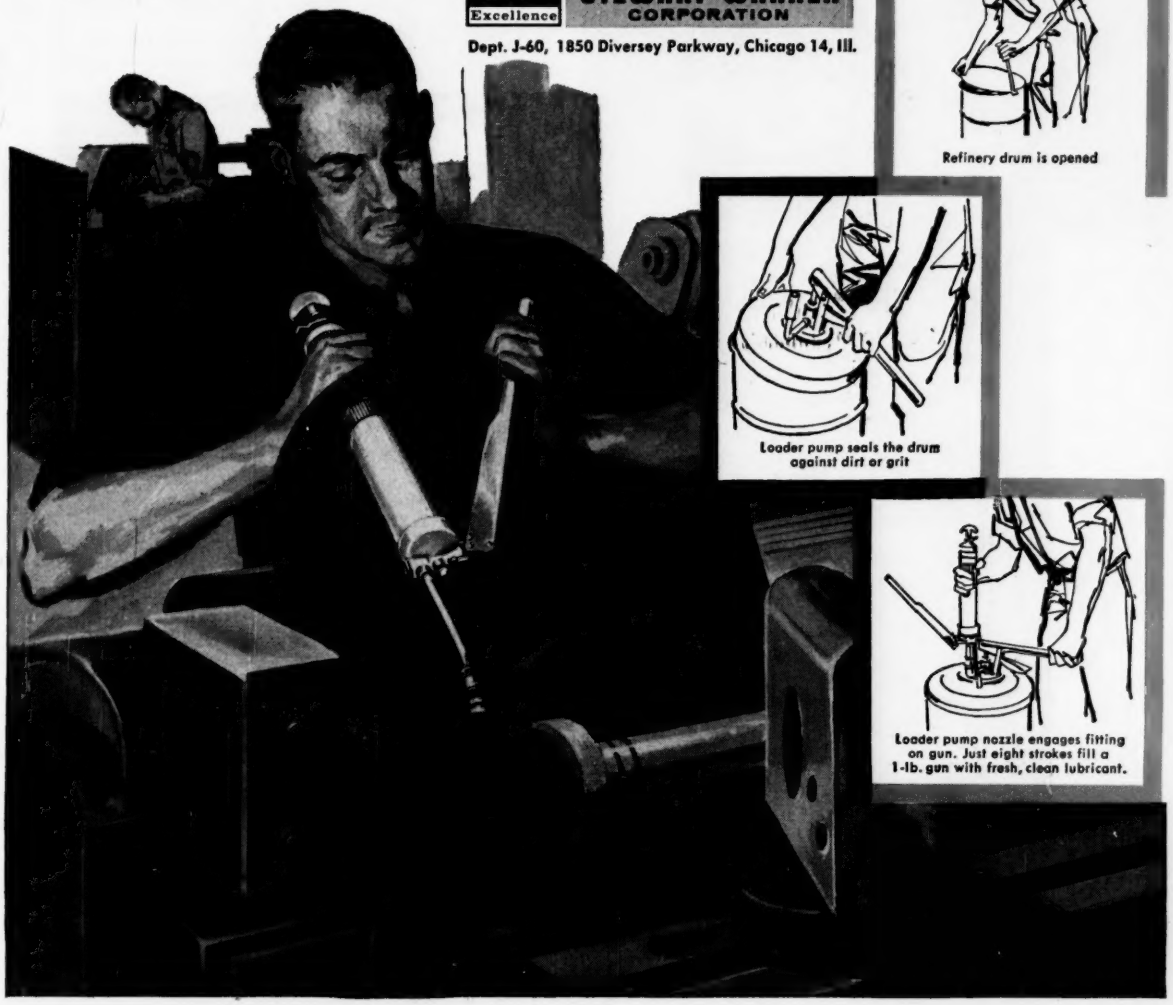
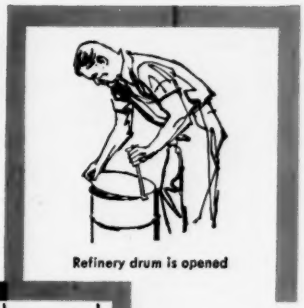


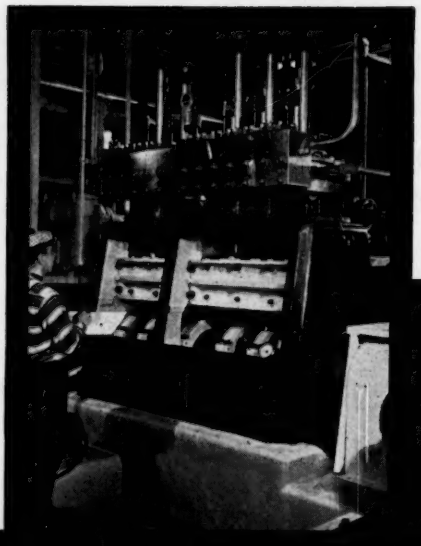


Refinery drum is opened

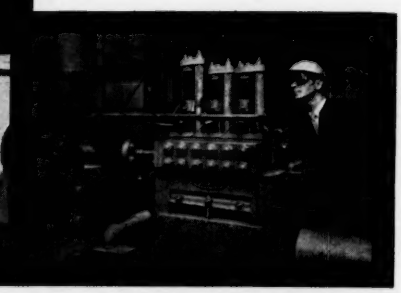
Loader pump seals the drum against dirt or grit

Loader pump nozzle engages fitting on gun. Just eight strokes fill a 1-lb. gun with fresh, clean lubricant.

WHAT'S YOUR SPECIAL PROBLEM IN PUMPING?

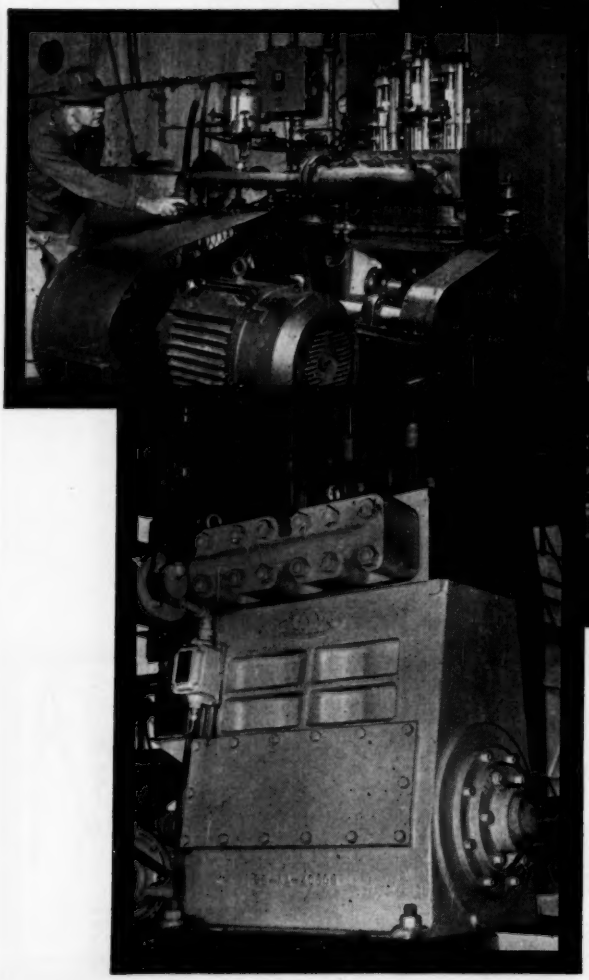


Special nylon ball valve and stainless steel fluid end handle silica gel at 1800 psi.



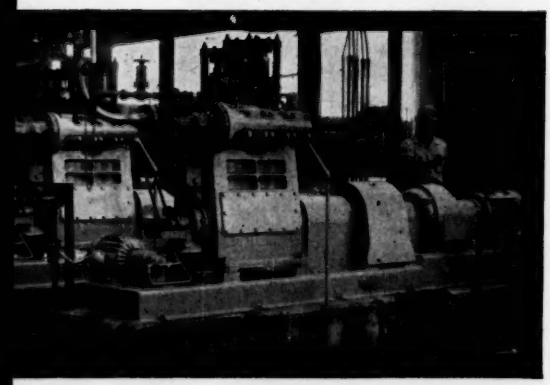
Here, Aldrich pumps continuously control the flow of liquid ammonia at 3700 psi.

This Aldrich pump handles highly corrosive chemicals—both alkaline and acidic.



To handle, alternately, caustic and brine, at 3000 psi, this Aldrich Triplex pump has entire fluid end of Monel.

Aldrich pumps with nickel alloy fluid end pump 50% caustic soda solution at 400 psi.



Corrosives? Slurries? High pressures? High temperatures? We'll find the answer!

All pump companies sell pumps. And all have their share of pumping problems. At Aldrich, our most important stock in trade is our ability to solve the rough pumping problems of the process industries. We've had over 50 years of working with chemicals and chemical processes. We know the problems of pump wear; of temperature, corrosion, viscosity; and your need for sustained pump operation. We study all the factors in your problem, in depth . . . and come up with a *better* answer, not merely *an* answer. For information on capacities, pressures and sizes, see our insert in *Chemical Engineering Catalog* or write for reprint (Data Sheet 100). ALDRICH PUMP COMPANY, 3 Gordon Street, Allentown, Penna.

The tough pumping problems go to ALDRICH

ONLY VISIBLE BLADES GIVE YOU SAFETY YOU CAN SEE!

• The men who pull the switches will tell you what can happen when a switch, *believed* to be open —*isn't*. A lot of things can happen—and every one of them is bad. Personnel safety is in jeopardy. Motors can single-phase. Machinery and work can be damaged. Down-time can skyrocket.

Doesn't it make sense to insist on Visible Blade construction which gives you a road block against any of those possibilities? Doesn't it make equally good sense to insist on the safety switch which gives you that construction—plus a lot of other performance advantages? Evidently it does, because *Square D switches have never been out of first place in more than 50 years!*

They cost no more...why settle for less?

MAIL the coupon for latest Safety Switch Bulletin

Square D Company, Dept. SA-124
1601 Mercer Road, Lexington, Kentucky

Please send me your latest SAFETY SWITCH BULLETIN

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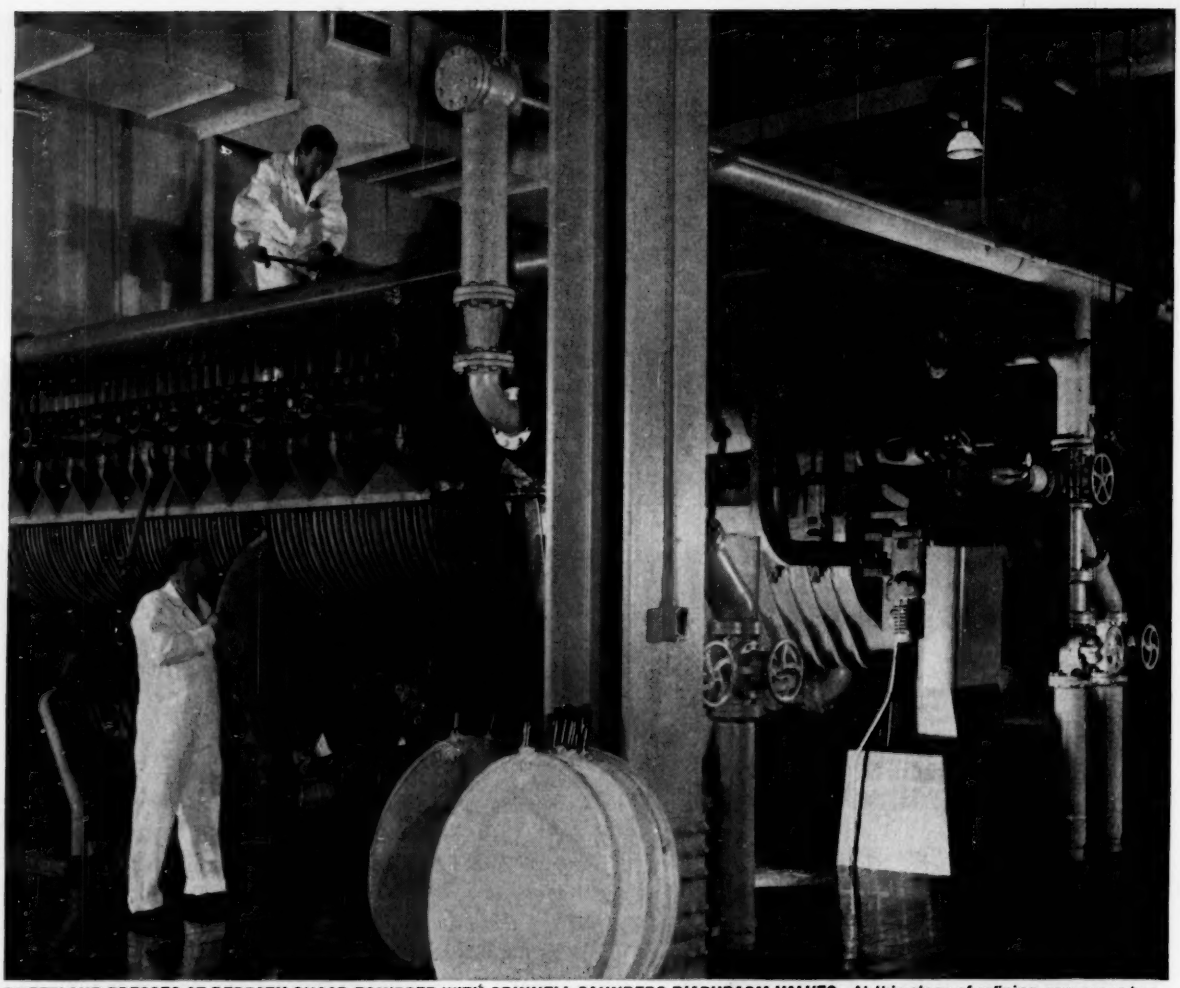
wherever electricity is distributed and controlled



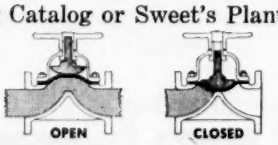
SWEETLAND PRESSES AT REDPATH SUGAR EQUIPPED WITH GRINNELL-SAUNDERS DIAPHRAGM VALVES—At this stage of refining, raw sugar has already been washed, dissolved, mixed with lime — and the lime and impurities in sugar precipitated with carbon dioxide gas. The resultant mixture is filtered through the Sweetland press to remove precipitant. Workmen are shown replacing the leaves in one of the Redpath Sweetlands.

Keeps sugar crystals from abrading working mechanism, avoids valve sticking, and prevents product leakage

A big problem in refining sugar is to prevent damage to the working mechanism of the usual type of valve by the eroding action of sugar crystals. Failure to do this means that sooner or later valves won't close tightly — resulting in messy, unsanitary, costly-to-repair leaks.

At Canada and Dominion Sugar Company's Redpath Refinery, in Toronto, Canada, Grinnell-Saunders Diaphragm Valves help avoid these problems. The diaphragm separates working parts from the fluid stream — preventing erosion of valve mechanisms on the one hand, and sticky or "frozen" valves on the other.

Grinnell-Saunders Diaphragm Valves are available in a wide range of body, lining and diaphragm materials. For more details, see Grinnell's insert in Chemical Engineering Catalog or Sweet's Plant Engineering File — or communicate with the Grinnell Company.



GRINNELL-SAUNDERS DIAPHRAGM VALVES

GRINNELL COMPANY, PROVIDENCE 1, R. I. • BRANCH WAREHOUSES AND DISTRIBUTORS FROM COAST TO COAST
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unmatched experience in the design and fabrication of

PROCESS EQUIPMENT

in all metals

Quick Opening **DOORS FOR PRESSURE VESSELS**

Another Struthers Wells specialty which features super-safety and quick-opening (15 seconds) operation. Ask for Bulletin SW 553.

Whatever your problems may be in process equipment and process systems, Struthers Wells' engineers will be happy to discuss them with you. Struthers Wells has unsurpassed leadership in design and fabrication, including welding of all types of stainless steel, nickel, Hastelloy, Monel, Titanium, T-1 and many other proved materials. Take advantage of this experience. Our recommendations may save you time and money.

For additional information and address of your local Struthers Wells representative see Chemical Engineering Catalog, pages 1541 to 1560, or write us for Bulletin CN-559.

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TITUSVILLE, PENNSYLVANIA

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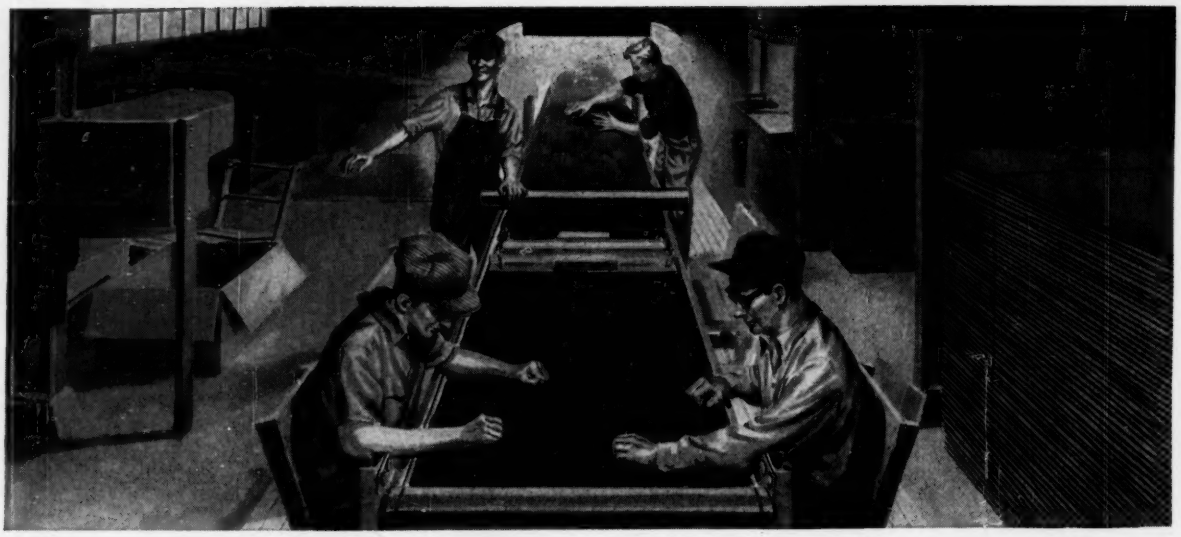
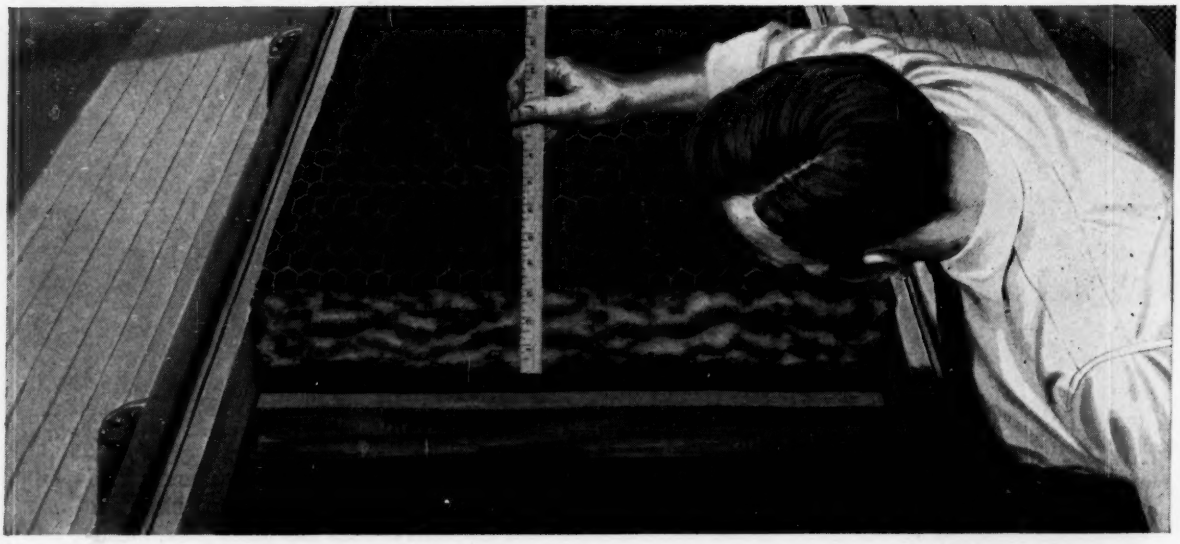


FACTORY FABRICATED TO RIGID SPECIFICATIONS!



Don't risk efficiency with careless, made-on-the-job blankets.

- Copper bearing steel laths, bound by uniformly spaced soft-drawn galvanized tie wires, keep blankets firm but flexible.
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- Completely free of large voids usually found in field-made blankets where insulation is haphazardly packed in place.
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- Quickly applied to flat or slightly curved surfaces of any large equipment—or cut to fit irregular areas.
- Maximum thermal efficiency at temperatures as high as 1200 F.

Eagle-Picher produces a complete line of industrial insulations for all temperatures from below Zero to over 2000 F.

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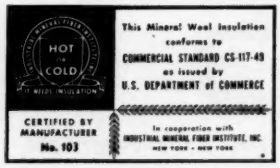

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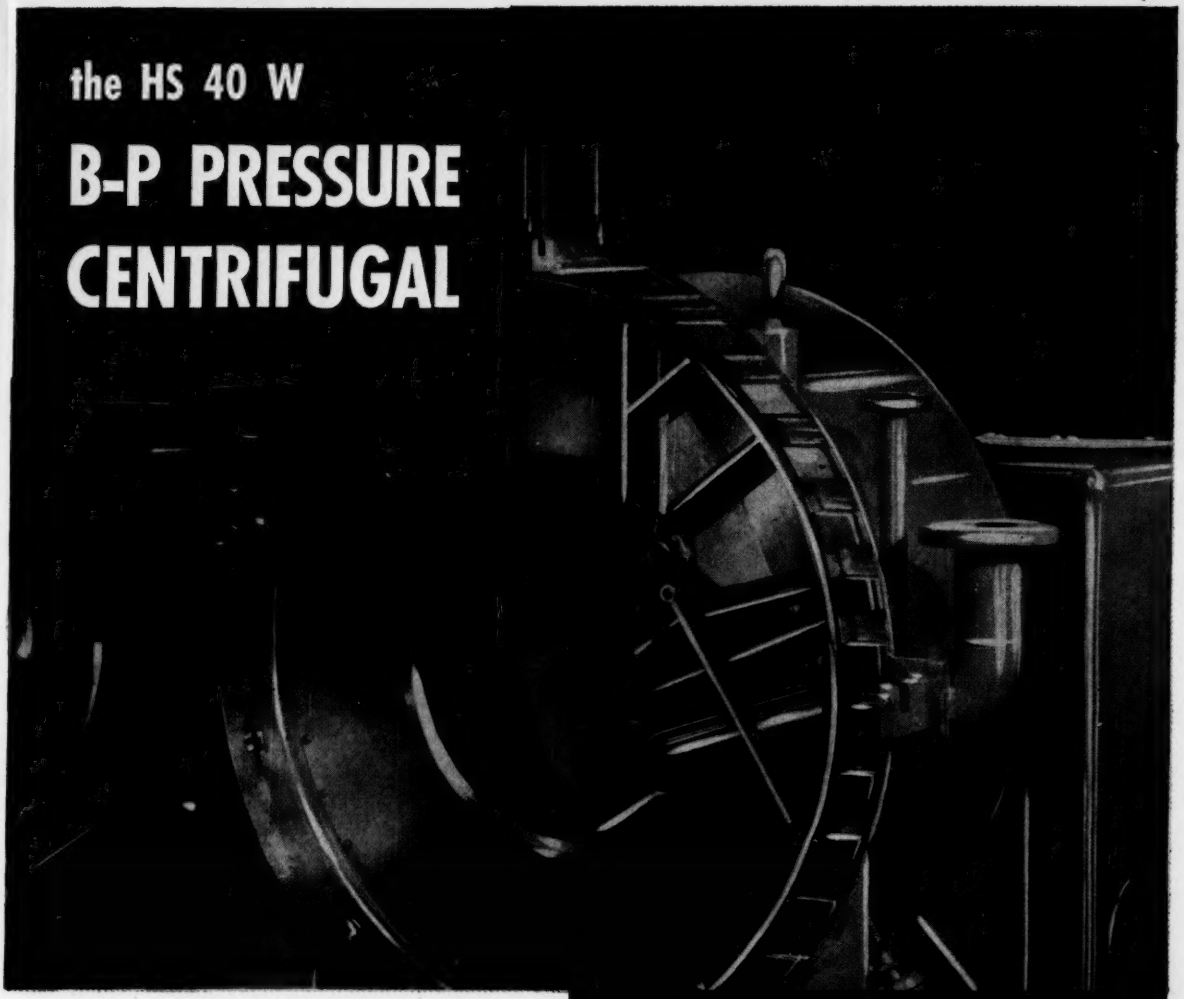
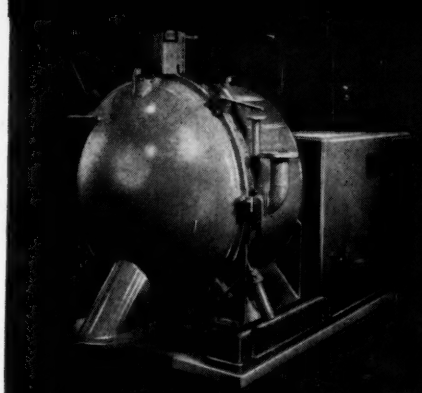
the HS 40 W

B-P PRESSURE CENTRIFUGAL



BAKER PERKINS research now brings you the HS 40 W Universal Pressure Centrifugal, engineered for normal operation at 1000 times gravity and internal pressures to 150 psi. Several important features are entirely new: A MECHANICAL SELF-BALANCING SHAFT SEAL is positioned where the main shaft enters the housing and is the only major moving seal. A CLAMPING AND SELF-ALIGNING DOOR SEAL consisting of a floating ring plus two O-rings assures a completely safe lock without the necessity of tightening bolts. A SIMPLIFIED DESIGN OF THE DISCHARGE KNIFE AND CHUTE. Complete discharge of all solids is effected, eliminating swirling or dusting of solids within the housing. PROGRESSIVE PEELING. For the first time, provision is made for the peeler knife to enter the cake at successively increasing depths. Glazing of the heel is eliminated. Air displacement is controlled during both the charging and peeling operations.

As in all Baker Perkins Universal Centrifugals, the interior of the new model is completely and readily accessible. For complete specifications of the high capacity HS 40 W Universal Pressure Centrifugal, see your B-P sales representative or write to:



BAKER PERKINS INC.

CHEMICAL MACHINERY DIVISION
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394

Send for free brochure, PARTLOW CONTROLS . . . A handy, condensed catalog of the complete line of Partlow temperature controls and allied equipment for industrial heating and refrigeration.

FAST, ON-TARGET DELIVERIES . . .

Another reason why more firms than ever are using Partlow Temperature Controls

Much of Partlow's business involves special controls to solve special application problems.

No matter how off-standard the control, however, the odds are better than 99-to-1 that the Partlow you order will be delivered well within our regular 3-to-4 week schedule. During the past 12 months — the busiest in our 40-year history — 99% of all the controls we produced went out *on time*, or ahead of it!

Of course, prompt, dependable delivery is only one reason for the mushrooming demand for Partlow products. Here are a few others:

Mercury Actuation, which lets the Partlow function without an outside power source or temperamental electronic amplification . . .

Unmatched Design Simplicity, which enables the Partlow to withstand even extreme conditions of shock, vibration, corrosion, dust and moisture, without loss of accuracy or sensitivity . . .

Interchangeability of Elements, which makes it possible for any Partlow to be serviced at the job site, virtually eliminating "down time."

Partlow makes a complete line of electric, mechanical and pneumatic controls (recording, indicating and non-indicating) for temperatures up to 1100°F. Whatever your application problem, Partlow makes an instrument to handle it efficiently, economically, *precisely*. Write for details: The Partlow Corp., New Hartford, N. Y., Dept. **E-610.**

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TEMPERATURE CONTROLS
World Export:
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ADDED SAFETY is an important benefit when you equip your loading rack with the only gear-driven swivel joint on the market. No danger of the operator slipping on wet or icy decking while pulling down a loading arm. No chance of arm dropping or rising unexpectedly to spill hot or caustic products. No counterbalance arms, cables or pulleys to endanger clearance on the platform. The entire loading operation is constantly controlled by this easy-to-crank joint.

TROUBLE-FREE SERVICE offers an equally important advantage. This gear-driven swivel joint incorporates all the proven features of C-E's popular US-Type Joint. It breaks like a union for quick, easy repairs on location without special tools. No need to disturb bearings when repacking. Wide-spaced bearings and non-split races last longer and permit greater foot/pound loading. Separate races can be reversed easily to double their life.

C-E Gear-Driven Swivel Joints are available in 2, 2½, 3 and 4 inch sizes — styles 3, 4, 5 and 6 — in mild steel or with stainless steel wettable parts.

For more years of service, less maintenance expense and a safer loading rack, equip it entirely with Continental-Emsco's Gear-Driven Swivel Joints. There's a size and type to meet every requirement.

Write, call or wire for the full catalog and price information.

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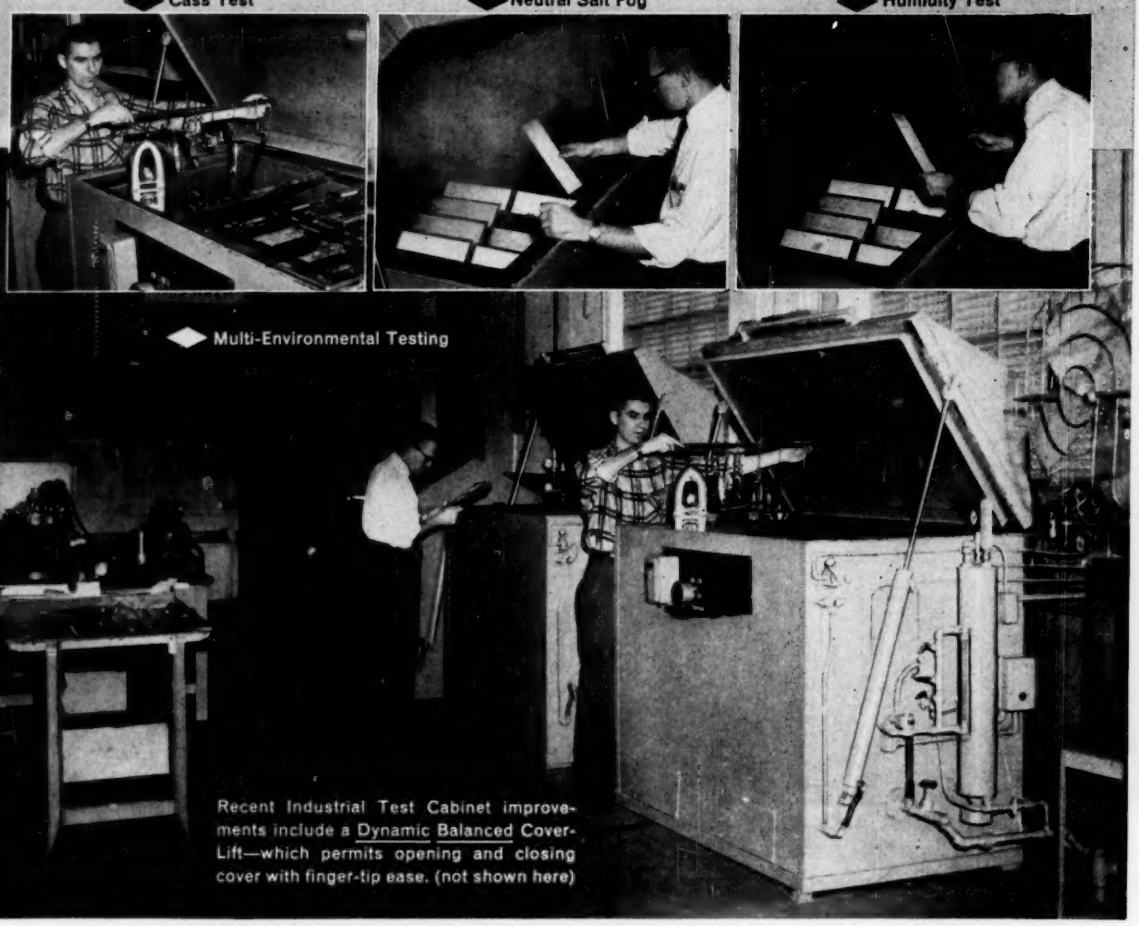
American Motors Fights Corrosion with INDUSTRIAL Test Cabinets


Cass Test
Neutral Salt Fog
Humidity Test
Multi-Environmental Testing
Recent Industrial Test Cabinet improvements include a Dynamic Balanced Cover-Lift—which permits opening and closing cover with finger-tip ease. (not shown here)

Rigid accelerated corrosion tests show reliability of Type 411 Cabinets

Corrosion resistance comes under conscientious control at American Motors. Typical of their emphasis on serviceability and long life for the RAMBLER product is their attention to the environmental testing of plated and painted parts.

Among recent test equipment additions to their production test facility at Kenosha, Wisconsin, were three of our new Type 411 Corrosion Test Cabinets. Particularly suitable for this auto manufacturer's needs, Type 411 is versatile enough to meet all the essential requirements for neutral salt fog, humidity and "Cass" corrosion tests.

The vulcanized, rubber-lined cabinet is of double wall construction to provide uniform temperature within the test area. All saturation and heating processes are under positive control. Relative humidities of 95 to 100% from ambient temperatures to 125° are routine.

Close cooperation with government and the military; ASTM, AES, and conformity to most federal and commercial requirements, specifications and procedures have placed the new INDUSTRIAL Type 411 Test Cabinets in demand . . . *wherever* environmental simulation and accelerated corrosion tests serve improved quality control standards.

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CP-180

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5918 Ogden Ave., Cicero 50, Illinois

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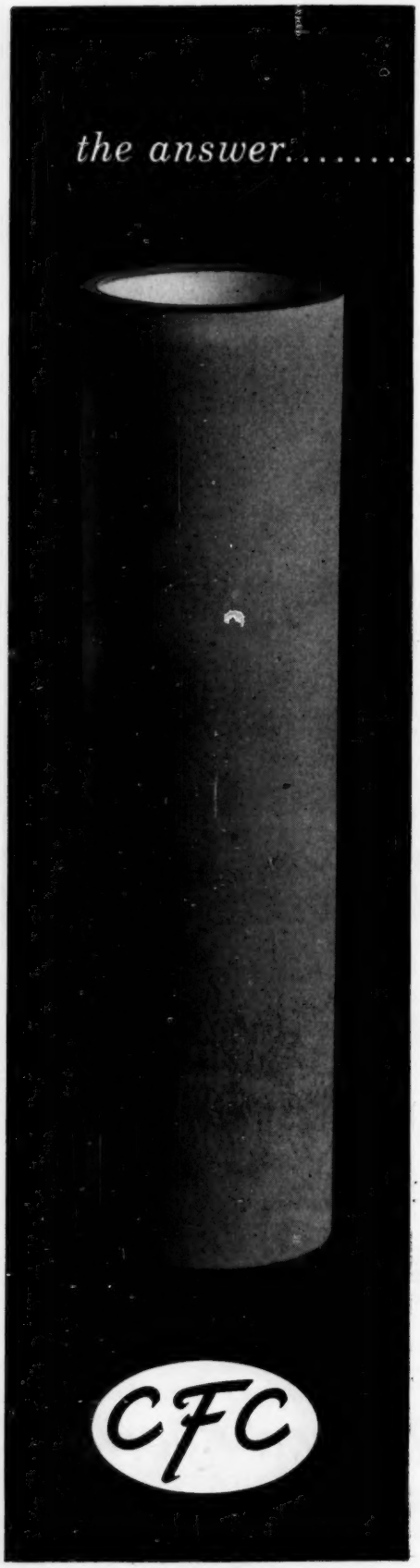

the answer.....to 6 difficult filtration problems

NEW CFC POROUS CERAMIC FILTER ELEMENT

Inert, stable • corrosion resistant • heat resistant • re-usable • resistant to high differential pressures • uniform pore size • wide selection of particle ratings

1. **ACIDS** — *CFC Porous Ceramic Element* installed in a plastic lined filter container is a unique combination for all acids filtration other than hydrofluoric.
2. **FOOD PRODUCTS** — *CFC Porous Ceramic Element* imparts no taste, odor or toxicity.
3. **NUCLEAR REACTOR SYSTEMS** — *CFC Porous Ceramic Element*, with exceptional characteristics of controlled porosity, inertness, elimination of media migration, is equipped to handle critical reactor system clean-up, storage and reactor pool filtration, reactor exhaust vent filtration.
4. **PHARMACEUTICALS** — *CFC Porous Ceramic Element* for clarifying, polishing, cold sterilization of biologicals, serums, allergenic extracts, etc.
5. **PLASTIC RESINS** — *CFC Porous Ceramic Element* for effective resistance to high differential pressures (up to 600 psig) on high viscosity fluids.
6. **SOLVENTS** — *CFC Porous Ceramic Element* removes linters, fibers or floaters, prevents discoloration by leaching of organic material from other filter media.

CFC Porous Ceramic Filter Elements are manufactured in 1, 5, 10, 25, 50, and 100 micron pore sizes to fit all CFC containers; also available in Cylinder, Disc, Cup and Sheet form.

CFC Porous Ceramic Filter Element has been the solution to many difficult filtering problems involving heat resistance, mechanical strength, resistance to chemical attack, and critical porosity control. It could be the answer to one of your filtering problems. For complete information, write to Dep't CE.

Filter out high costs . . . with CFC Filters

COMMERCIAL FILTERS CORPORATION

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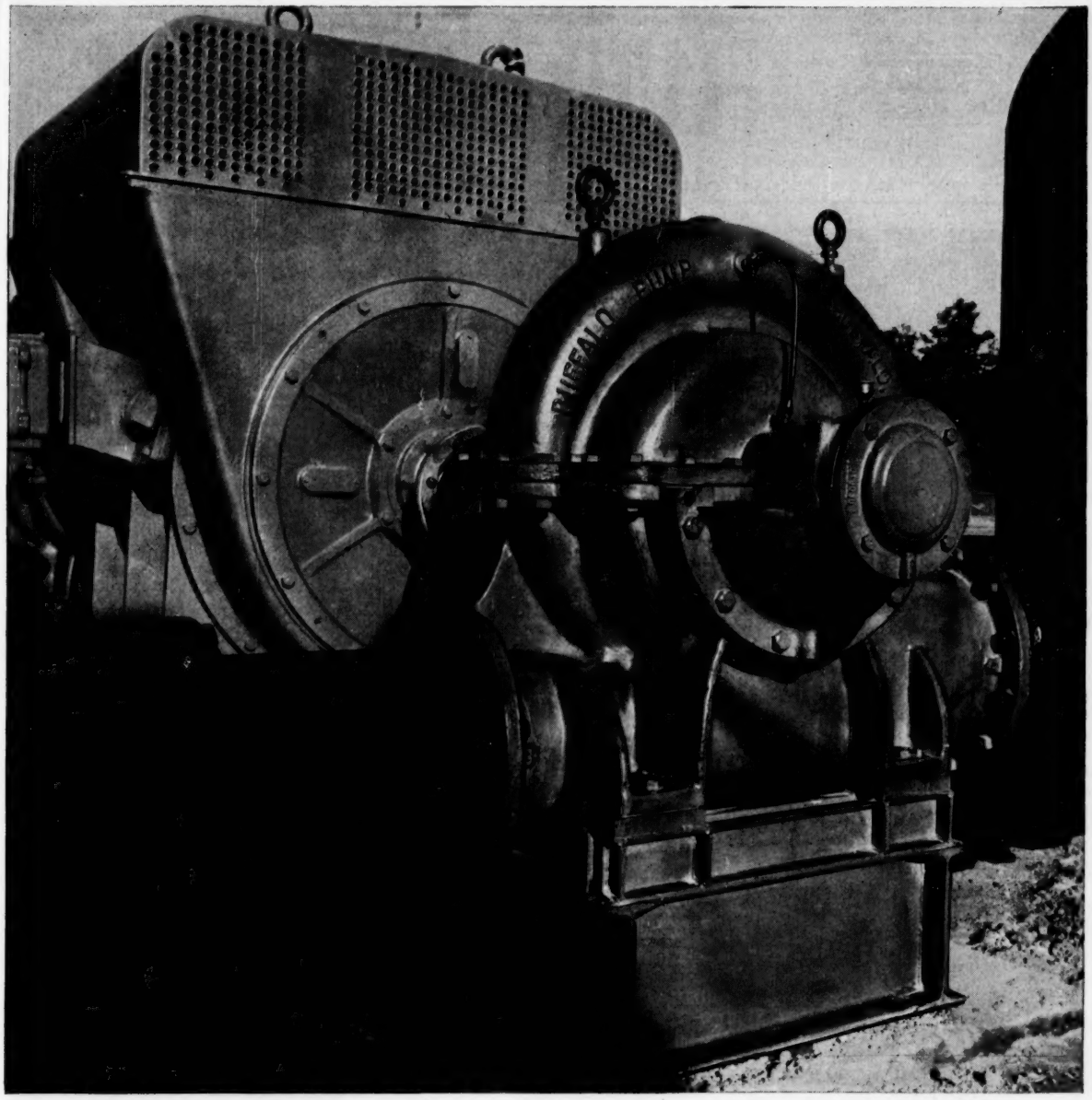
PLANTS IN MELROSE, MASSACHUSETTS AND LEBANON, INDIANA



1 of 3 'Buffalo' Pumps delivering a total of 1,500,000 gallons every day to a major paper mill day after day.

Big pumps, small pumps, in most materials, every job, every industry—our Buffalo Pumps Division has excelled in this for over 83 years. Write direct or call in a Buffalo representative.

"Buffalo" PUMPS

BUFFALO PUMPS DIVISION

Buffalo Forge Company • Buffalo, New York

Buffalo air handling equipment to move, heat, cool, dehumidify and clean air and other gases.

Buffalo Machine Tools to drill, punch, shear, bend, slit, notch and cope for production or plant maintenance.

Buffalo Centrifugal Pumps to handle most liquids and slurries under a variety of conditions.

Squier machinery to process sugar cane, coffee and rice. Special processing machinery for chemicals.

RODNEY HUNT

FLUID PROCESSING

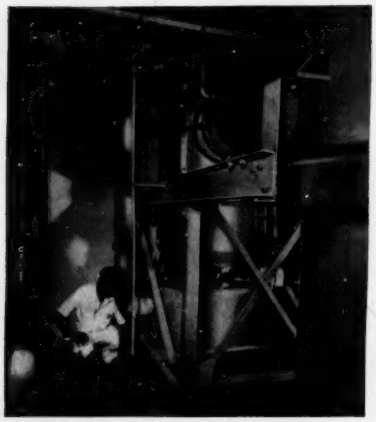
RODNEY HUNT MACHINE CO., Process Equipment Division, 10 VALE STREET, ORANGE, MASS.

RODNEY HUNT PROCESSORS APPLICABLE TO WIDE RANGE OF INDUSTRIES AND PRODUCTS

Rodney Hunt Turba-Film® Processors have proven to be extremely versatile not only in the range of industries and products they serve, but also in the different kinds of processes they perform. Processors of chemicals, petroleum, pharmaceuticals, food and many other products have found in the Turba-Film Processor the key to successful production. These mechanically aided thin-film processors assure closely controlled uniformity of product in processes such as: concentration . . . deaeration . . . distillation . . . steam distillation . . . deodorization . . . liqui-solids . . . desolventization . . . and homogenization.

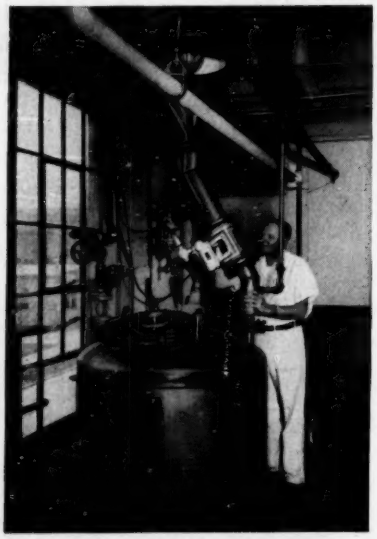
In one pass—continuously and rapidly—the Rodney Hunt Turba-Film Processor provides heat and mass transfer for processing liquids and slurries. Since product quality can be checked continuously, production errors and costly re-runs of reject material are eliminated.

On this page are illustrated three typical installations of Rodney Hunt Turba-Film Processors: in *chemicals* . . . in *food* . . . and in *pharmaceuticals*. At the bottom of the page are some of the major American manufacturers who are using the Rodney Hunt Turba-Film Processor to help solve complex processing problems.

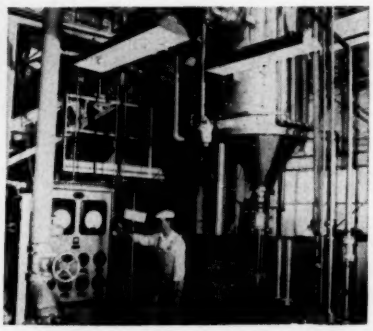


IN CHEMICALS . . .

In the biological and chemical laboratories of a New Jersey manufacturer, the Turba-Film Processor is extensively used to concentrate products coming from extraction or ion exchange columns. Formerly a batch process, the Turba-Film unit now makes this a continuous operation. In addition to eliminating three vats required by the original process, other operating advantages are reported: product quality is superior; several products are processed consecutively with only brief cleaning periods; evaporation takes place below 90°F., preventing degradation of heat-sensitive antibiotics; capacity is increased, speeding output; and with complete Rodney Hunt instrumentation, the unit requires a minimum of attention and manpower.



The top photo above shows the upper end of the processor, the photo below the discharge end.



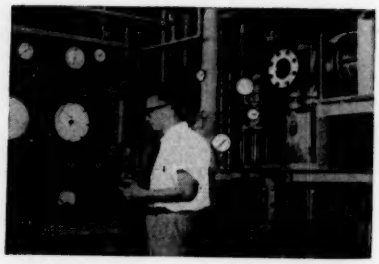
IN FOOD . . .

This Turba-Film Processor produces superior quality fruit concentrates at a rate of 5 tons per hour in a packing plant on the West Coast. Operating 24 hours a day during the peak season, the processor maintains an excellent operating record with a minimum of maintenance.

The taste and quality of the concentrates produced are protected from the injurious effects of overheating because of the precisely controlled, short-time exposure of the product in the thermal section. As with other applications, the Turba-Film Processor consistently and automatically retains the essential properties and desired qualities of the product being processed.

IN PHARMACEUTICALS . . .

A manufacturer of pharmaceuticals encountered product discoloration and loss of product prior to placing a bacteria-killing drug into full production. This problem was solved by replacing conventional evaporator with a Rodney Hunt Turba-Film Processor designed to handle the heat-sensitive product. The Turba-Film Processor helps turn out a uniform top-quality pharmaceutical product.



SOME WELL-KNOWN COMPANIES USING TURBA-FILM PROCESSORS . . .

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United States Rubber Company
Union Carbide & Carbon Corp.

DEVELOPMENTS . . .

JUNE 13, 1960

Chementator

T. PETER FORBATH

Though Union Carbide declines to comment, it's reliably reported that company will apply closed-loop digital-computer control to its ethylene oxide plant at Seadrift, Tex.

Mobil Oil becomes second firm to market tetramethyl leaded gasoline. Following closely California Standard's move (Chementator, May 16, p. 69), Mobil last month began offering Mobilgas Special with "Methyl" at its Syracuse, N. Y., area service stations.

Petro-Tex Chemical has developed new maleic anhydride process based on oxidation of low-cost C_4 feed rather than usual benzene. Company is building 30-million-lb./yr. plant due on stream in mid-1961.

More natural-synthetic-rubber activity

Two more companies have bounced into the natural-synthetic-rubber market. After several years of pilot planting, Goodyear Tire & Rubber now reports that it will erect a $20-$25-million plant near Beaumont, Tex., to make both polyisoprene and polybutadiene. Capacity is estimated at 30,000 tons/yr.; plant is expected to be on stream in mid-1961.

Second firm connected with the Goodyear venture is Scientific Design Co. (New York), which will supply process design. Though Goodyear says only that it has "worked closely" with SD, a good bet is that SD's contribution will be in the production of high-purity isoprene. Raw material for polyisoprene plant (probably isoamylene as in Shell's Torrance, Calif., facility; *Chementator*, Mar. 7, p. 51) will come from Mobil Oil's Beaumont refinery as will polybutadiene feedstock.

Still another firm indicating an eagerness to get into the synthetic-natural-rubber picture is Humble Oil & Refining, *CE* learns. Company, already producing low-purity isoprene for butyl rubber, has piloted an isoamylene dehydrogenation process for the production of polymerization-grade isoprene. And it's now negotiating with several potential polyisoprene producers to supply their feed.

Engineers vote to bury unionism

If an epitaph for engineering unionism is ever written, May 10, 1960, may be recorded as the day engineers started nailing the lid on the coffin. For that day, by a vote of 3,790 to 2,603, engineers employed by Western Electric decided in a worldwide election to bar certification of the Council of Western Electric Professional Employees-National as their collective bargaining unit.

One of the largest constituent unions of the Engineers & Scientists of America (roughly 6,750 members), CWEPE-N is its second to suffer defeat in a National Labor Relations Board certification election. Engi-

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EV Series
Explosion-Proof
Lighting Fixtures

Highest Efficiency . . . Easier to install, relamp, maintain . . .

The EV series offers exactly the right fixture for any area made hazardous by flammable atmospheres of vapors or gases, as defined under Class I of the National Electrical Code.

Basic EV Incandescent Fixtures
(Groups C & D)

are of strong, shock-resistant construction, contain internal explosions without rupturing. Threaded joints are flame-tight . . . no sealing compound required on installation. Gas tightness not required for safe operation . . . just turn off line current when relamping. Maximum corrosion-resistance. 75-500W.

EVA Incandescent Fixtures
(Groups A & B)

comprise the first complete, UL-approved lighting system for acetylene and hydrogen locations. Lamp and wiring compartments are separate and individually explosion-proof. 150-300W.

EVA Mercury Vapor Fixtures
(Groups C & D)

provide important operating economies in hazardous areas: *2.5 times more light output per Watt* than incandescents . . . greatly reduced frequency of relamping. 250-400W.

For Complete Information on Crouse-Hinds explosion-proof lighting equipment, call your Crouse-Hinds distributor, or write us. EV Lighting Fixtures are available in all reflector types: Holophane Prismatic (illustrated); slotted dome and angle; and conventional (unslotted) in all shapes and sizes.

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neers and technicians employed by Minneapolis-Honeywell wiped out a ten-year-old ESA organization when they voted "no union" in 1957 (*Chem. Eng.*, Aug. 1957, p. 316). But there were "extenuating circumstances" surrounding ESA's defeat at M-H and only 2,200 employees were involved.

Defeat of CWEPE-N culminates a 15-year pitched battle between Western Electric and the union. Of special significance to all engineers is the series of 39 formal hearings held by NLRB leading to the decision in March that a professional is identified by the work he performs, not by his training, experience, degrees or licenses.

New terephthalic process gets backing

Germany has come up with another process for making terephthalic acid.

Newest one, developed by Bergbau-Forschung (Essen-Kray), first chloromethylates toluene feed, then oxidizes resulting chloromethyl compound with nitric acid. Yield is an easily separated mixture of about 40% *o*-phthalic acid and 60% unusually pure terephthalic. Process recently moved into a 440-lb./day pilot unit. And product approval by an unidentified polyester fiber manufacturer (representing TA's big area of consumption) has given the project an encouraging boost.

Bergbau's venture comes hard on the heels of another German TA development. Last summer (*Chementator*, Aug. 10, p. 53) Henkel announced a flowsheet that starts with reaction between benzene and potassium carbonate.

Both of these processes, coming from petroleum-lean Europe, prudently steer clear of using *p*-xylene for their starting material. Shunning xylene may be a wise move for U. S. producers too, some industry observers feel. Reason: Pure *p*-xylene costs far more than either benzene or toluene. And using a less expensive mixed-xylene feed can lead—and has led—to product separation problems.

Bergbau initially reacts toluene, *p*-formaldehyde and 33% HCl at 158 F., then separates organic and aqueous phases. Organic phase goes to two-stage oxidation with HNO_3. First stage produces chlorine-free toluylic acids; second stage (at 20 atm., 320 F.) yields mixture of terephthalic and *o*-phthalic acids. Former crystallizes readily, is separated by centrifuging.

Company maintains that its product is purer than any other TA (e.g., 0.1% Cl, 0.1% N). And it claims a minimum of by-product and corrosion problems because of short reaction time and low acid concentrations. Moreover, process can be easily switched to production of trimellitic, pyromellitic or other aromatic acids, Bergbau declares.

Cryogenics makes ultra-pure methane

Cryogenics is quietly carving out a new processing niche for itself—the production of exceptionally high-purity methane via the low-temperature distillation of natural gas.

Latest evidence of this trend comes from Allied's Solvay Process Div. Firm currently is installing at Moundsville, W. Va., a 500-cu.-ft./min. facility, designed and built by Air Products (Allentown, Pa.), to refine natural gas into better-than-99.99% CH_4. Product will serve as feed for Solvay's chlorinated hydrocarbons plant at the site.

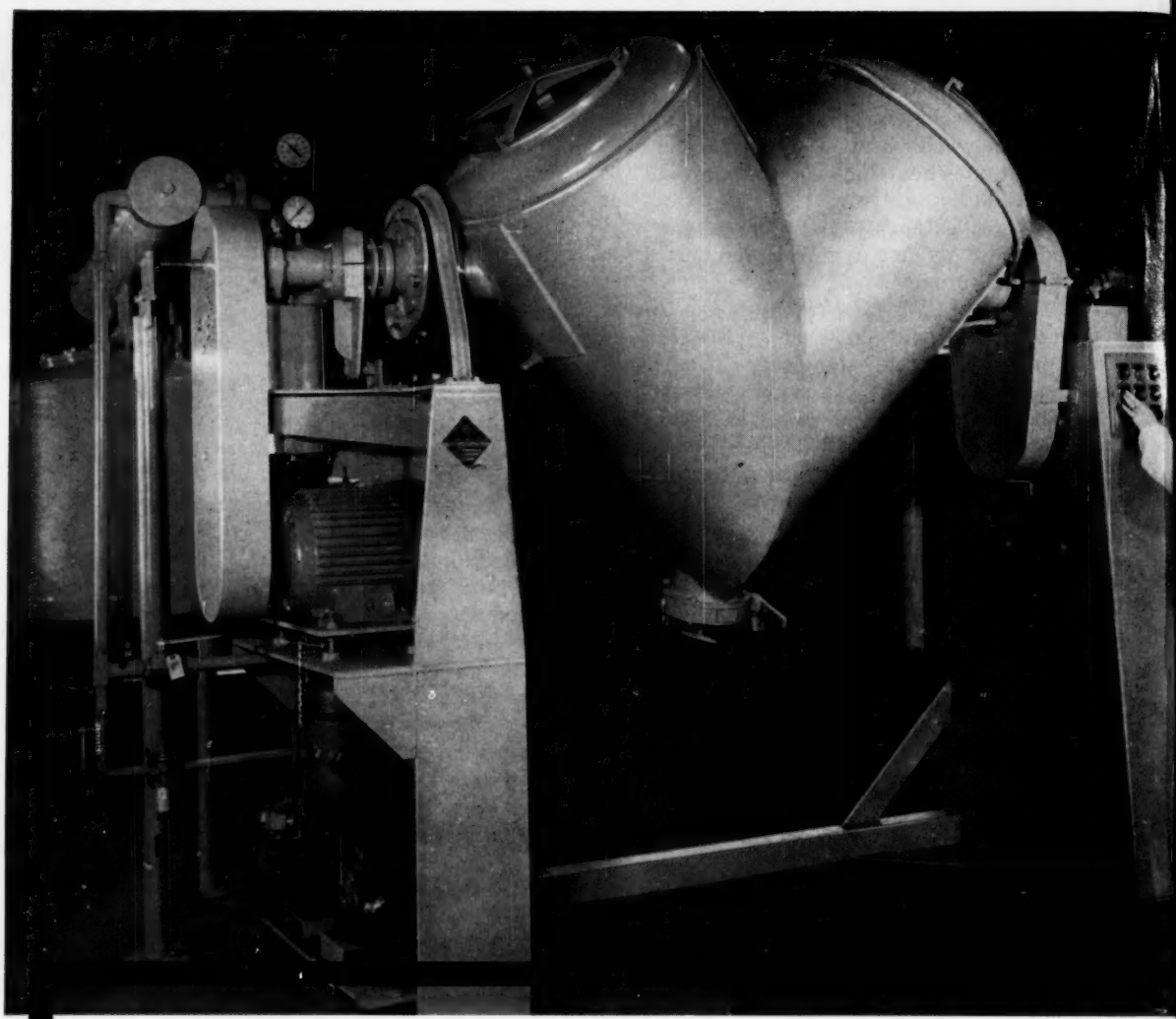
Solvay's installation marks the fourth of this type to go into commercial service. Air Products has built a similar low-temperature methane purification facility for Diamond Alkali at Belle, W. Va. And American Air Liquide (New York) has installed its version of cryogenic CH_4 purification for Frontier Chemical at Wichita, Kan., and Stauffer Chemical at Louisville, Ky. These plants, too, provide feed for the manufacture of chlorinated hydrocarbons such as carbon tetrachloride, chloroform, methyl chloride and methylene chloride.

Key advantage of cryogenic processes in this application over the conventional methane-purification routes lies in the "ultra-purity" methane that they're able to deliver to the chlorinating operation. Notes an industry observer, widely used ambient-temperature adsorption turns out methane of about 5-12,000 ppm. purity. Low-temperature (—40 F.) oil absorption gets product of around 1-2,000 ppm. purity. Cryogenic distillation, however, can produce methane of almost research-grade (100 ppm.).

Result: Cryogenics eliminates headaches that arise when substantial quantities of impurities in methane feed are chlorinated. For example, chlorination of ethane produces hard-to-separate, unstable compounds that create corrosion problems in plant and contaminate final products.

In cryogenic processes, natural gas feeds

(Continued on page 74)



Now for the first time you can combine vacuum-drying and liquid-solids blending in a single packaged unit – the new P-K Solids-Processor. This latest P-K "Twin-Shell" development dry blends solids, disperses liquids, granulates and dries in simple sequence.

DRY BLENDING – Solids are tumbled to give gentle precision blending. This may be done under vacuum or atmospheric conditions, in inert or sterilizing gas, with heat in jacket up to 200° F., or with cooling water circulated through jacket. When needed, intensive blending breaks up agglomerates or gives uniform dispersion of pigments.

LIQUID DISPERSION, GRANULATING – Minute or large percentages of liquid are uniformly dispersed into solids. Dispersion can be sufficiently intimate to provide lump-free production. Or it can be regulated to produce granulations of controlled size. As in dry blending, these steps can be conducted under vacuum or atmospheric conditions, in inert or sterilizing gas, with heat in jacket up to 200° F., or with cooling water circulated through jacket.

DRYING – The new packaged system allows vacuum drying of heat sensitive materials with continuous turn-over and re-blending of solids. During drying, small balls with an insulating crust that inhibits complete drying tend to form. A separately actuated agitator breaks these up, permitting drying to a finished fine powder. In final stages of drying, direct hot air or gas can be introduced to reduce liquid content quickly to a fraction of a percent.

All P-K Solids-Processor systems are completely packaged. Available in standardized models with charge capacities from one to fifty cu. ft.

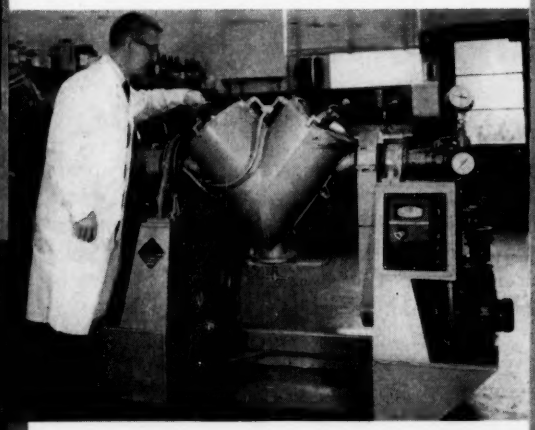
Revolutionary!

P-K Solids-Processor*

adds vacuum drying to liquid-solids blending...

Pre-test model available

We invite you to bring or send your materials to the P-K Pre-test Laboratory in East Stroudsburg. A one cu. ft. model of the new Solids-Processor is available for pre-testing . . . to demonstrate things impossible to see without pilot study . . . to work out subtle variables in blending, granulating and drying . . . to indicate accurately scale-up results and operational procedures . . . to predict savings in materials, labor and equipment investment.



Performs these operations:

1. Precision gentle blending
2. Intensive blending
3. Liquid dispersion in solids
4. Liquid-solids blending under vacuum
5. Granulation of solids
6. Dry blending under vacuum
7. Vacuum drying or cooling of solids
8. Heat sterilization of solids
9. Coating of solids
10. Chemical reaction under heat and vacuum
11. Direct gas drying

It's best if you can come yourself for pre-testing. You'll work with well-qualified engineers who have made thousands of resultful pre-tests for processors. They often suggest and produce unexpected product variations. Your guidance as to what is best for your product or process will be helpful. All you need is enough material for three separate one cu. ft. trial runs.

If you are unable to attend, send your materials. If possible, include a sample that will indicate optimum results. We'll give you a complete pre-test analysis.

Write or phone George Sweitzer collect at Stroudsburg, Hamilton 1-7500.

Patterson Kelley

Chemical and Process Equipment Division
112 Burson Street, East Stroudsburg, Pa.

*patented and patents pending

into a caustic scrubber for carbon dioxide removal, then enters alumina-packed dryer. Gas cools to about —200 F. in a coil-tube exchanger by passing against pure methane product and exiting fuel gas from methane distillation column. Cold gas is fractionated in cryogenic column; bottoms of heavy hydrocarbons and some overhead of pure methane recycle as coolant to exchanger. Rest of methane overhead is passed through a recycle heat exchanger as coolant, then is compressed to about 1,500-3,000 psi. This stream returns through recycle exchanger to be cooled by incoming product, then is expanded to form liquid for refluxing distillation column. Gas portion of reflux, removed in a phase separator, joins methane product stream.

Lined pipe: Goal of new techniques

With low-cost, corrosion-resistant metal pipe among the most coveted but hard-to-come-by items in the chemical process industries, a number of firms in recent months have begun stepping up development on new techniques for manufacturing lined pipe.

• Gray Tool Co. (Houston) is readying a hydraulic-expansion process to make lined carbon steel pipe for corrosive, high-temperature chemical-process service. Originally conceived by International Nickel, technique involves hydraulically expanding a thin metal sleeve inside a pipe casing to form a mechanically bonded lining. Gray will be offering lining materials of Monel, alloys of copper and nickel, stainless, titanium, tantalum and zirconium. Sizes will range up to 20-in. O.D. Dow at Freeport and Plaquemine, La., and Kaiser at Gramercy, La., have installed pipe made by this technique.

• Wolverine Tube (Allen Park, Mich.) is grooming its Strubing technique (*Chem. Eng.*, Sept. 7, 1959, p. 100) for the job of lining steel pipe. In this scheme, light-wall seamless tubing, as a flattened ribbon, is threaded through pipe casing, then either pneumatically or hydraulically inflated. As in the case of Gray Tool's technique, Strubing liners form mechanical bonds. Currently, Wolverine is testing 3-400-ft. lengths of 8-in.-O.D., schedule-40 Strubing-lined pipe in cooperation with a major U.S. caustic soda producer.

• International Nickel (New York) is researching a technique for fabricating lined pipe out of metal-plated steel billets. Chief work has been with nickel plating after which steel billet is hot rolled at about 2,000 F. into "small" diameter nickel-lined pipe. In this scheme, a metallurgically bonded lining is obtained.

• Phoenix Iron and Steel (Phoenixville, Pa.) is adapting the Italian-Calmes pipe-forging process to the job of making lined pipe. In company's variation, stainless steel sleeve is inserted into carbon steel "hollow". This then goes to forging mill where stainless is metallurgically bonded to steel casing. Though process is still under investigation, Phoenix expects to begin marketing 5-½ to 6-in. O.D. lined pipe in near future.

Cross-link polyethylene chemically?

Chemical cross-linking of polyethylene nets the same gamut of improved properties that irradiation does—but at considerably lower cost.

So, at least, feels Lucidol Div. (Buffalo, N. Y.) of Wallace & Tiernan, which has now started distributing developmental quantities of a substituted diperoxide catalyst for cross-linking high-density PE. Declares firm, catalyst can turn out a material with a temperature resistance equal to polyvinyl chloride and at a price eminently competitive with this widely used thermoplastic.

Currently, Godfrey L. Cabot, Inc. (Boston) is researching this type of catalyst for use in its Cab-XL process for making plastic pipe. Process involves mixing a peroxide cross-linking agent into PE resin along with carbon black, then melting in an extruder. Pipe is extruded continuously, heated to over 350 F. by a dielectric heater in the die. High temperature triggers catalyst and vulcanizes pipe.

Advantages claimed for the chemically cross-linked PE include high heat resistance (over 1,000 psi. hoop strength at 95 C. for 30 days), chemical inertness to aromatics and oxygenated compounds, high weather resistance and elimination of stress cracking. Low-cost potential of the material stems from its use of 50-75% carbon black at 4-6¢/lb. and only 1-2% of the cross-linking agent costing about 5¢/lb. PE resin.

Ship liquids in floating nylon bag

U. S. observers got their first look at the unique Dracone flexible barge last month in a demonstration at New York. With the co-

HANDLES 32% HCl AT AMBIENT TEMPERATURES—Workman is painting a section of Fibercast Pipe bearing 32% HCl at a Shell chemical plant. Note that Fibercast has sufficient strength for installation on span racks with the spacing normally used for metal pipe.

New pipes handle temperatures and pressures where no other pipes will do

WHAT is Fibercast?

It is a centrifugally cast, thermoset, epoxy resin reinforced pipe that handles temperature and pressure problems where no other non-metallic pipe will do. Its body of woven glass fibers resists high tension forces, is imbedded and bonded by heat in epoxy resin. Result: strong, long-lasting pipe that resists high pressure and temperatures in corrosive environments.

WHERE should Fibercast be used?

The petroleum industry . . . chemical . . . petro-chemical . . . nuclear energy . . . textile . . . paper . . . and food-processing industries . . . countless operations handling acids, alkalies, salt water and other corrosive liquids under pressure.

Wherever ease of handling, lightweight, dielectric properties and structural stability are desirable in a material that is at the same time outstandingly resistant to heat, pressure and corrosion.

WHY use Fibercast?

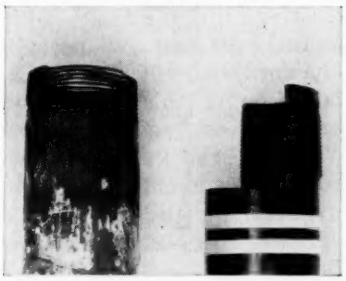
Because its advantages of superior resistance to heat, pressure and corrosion give Fibercast long service life that would alone justify choosing it over other materials.

Because even more expensive metal pipe or pipe with thermoplastic interior coatings cannot match Fibercast's proven durability.

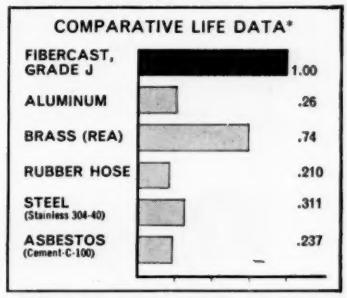
Because case histories and accurate testing have proved over and over again that Fibercast performs better, lasts longer, costs less.

Because out of 338 common corrosive solutions, Fibercast competently handles 320.

And, naturally, because Fibercast's unique and lasting qualities under such conditions mean that it drastically reduces maintenance and replacement costs, too.



Fibercast Tubing (right) used to suspend a 1,200 lb. pump for 3 years in a salt water supply well. *There was no loss in strength.* The damaged plastic-coated steel nipple (left) was used in the same installation, failed after 3 months service.



**Basing Fibercast as unit life of 1 and others as comparative percentages thereof.*

Remember, also, that the three major systems of joining all pipe are used with equal success on Fibercast (standard flanged, cemented, and threaded and coupled), and with a complete selection of Fibercast Fittings. It's the world's largest line of corrosion-resistant epoxy pipe fittings!

To receive a free sample of Fibercast, to learn more of the details, and to get specific information about how Fibercast can help *you*, mail the coupon below.

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FIBERCAST® COMPANY

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operation of Esso Standard, Dracone Operations, Ltd. (London), showed how to float 10,363 gal. of heating oil inside a 2,500-lb., 0.15-in. rubber-covered nylon bag from one marine terminal to another.

Starting with the 5-ft.-dia., 100-ft. bag on a reel, demonstrators placed it in the water, loaded it, towed it across the harbor, unloaded it, ballasted it with CO_2 and returned it to the original loading point. For the observers, demonstration indicated that marine transport of some low-gravity liquids can be as simple as floating a log.

For the past 18 mo. Esso Petroleum Co., Ltd., has used four of these Dracone bags to transport gas oil, diesel oil and kerosine from its Fawley, England, refinery to the Isle of Wight. Others are in use in Southeast Asia; one is scheduled for use in Japan.

Most likely application for Dracones is where navigation channels are shoal, docks limited or bridges low. Prices range from $14,110 for 35-ton unit to $55,455 for 320-ton unit with reductions up to 30% per unit for orders of six or more. However, use of Dracones in U. S. awaits Coast Guard approval based on report filed by officers present at New York demonstration.

Tomorrow's Technology

Today's embryonic developments which have special significance for chemical engineers

Zinc fuels latest fuel cell entry

At least one expert has observed that the fuels presently being used in fuel cells (e.g., propane, hydrogen) are *not* the ones that will lead to economic commercialization of this much-researched power-generating technique (*Chementator*, May 2, p. 56). With this a rapidly widening view, it's not hard to understand why Exide Industrial's new fuel cell, unveiled earlier this month, raised a greater flurry of interest than word of still another fuel cell development might have been expected to do. For Exide, markedly departing from the conventional, has named zinc as the fuel for its fuel cell.

Along with zinc, Exide uses low-pressure oxygen as oxidizer, potassium hydroxide as electrolyte. Electricity is produced by oxidation of zinc electrode. Company has demonstrated this novel scheme in an 18-cell, 1.5-v./cell unit, operating at 80% efficiency delivering 2 kw. of power. Mounted along with an oxygen cylinder, the "execptionally" compact power package has been used to drive a small (total weight: 200 lb.) racer for 16 hr. of continuous operation.

Claims Exide, zinc-oxygen cell offers some notable advantages over the more usual fuel cell types. For example, it operates at near ambient temperatures and pressures, thus avoids excessive corrosion. Too, it's rechargeable, thus eliminates need for waste removal. And it can be produced in a variety of shapes and on a mass-production basis, has higher electrical conductivity than other fuel cells, offers more uniform reactivity over the current-producing surfaces.

Exide's cell is described as being a minimum of two years away from commercialization. Company has signed agreements with 12 manufacturers of materials handling equipment to jointly develop its unit to power industrial trucks.

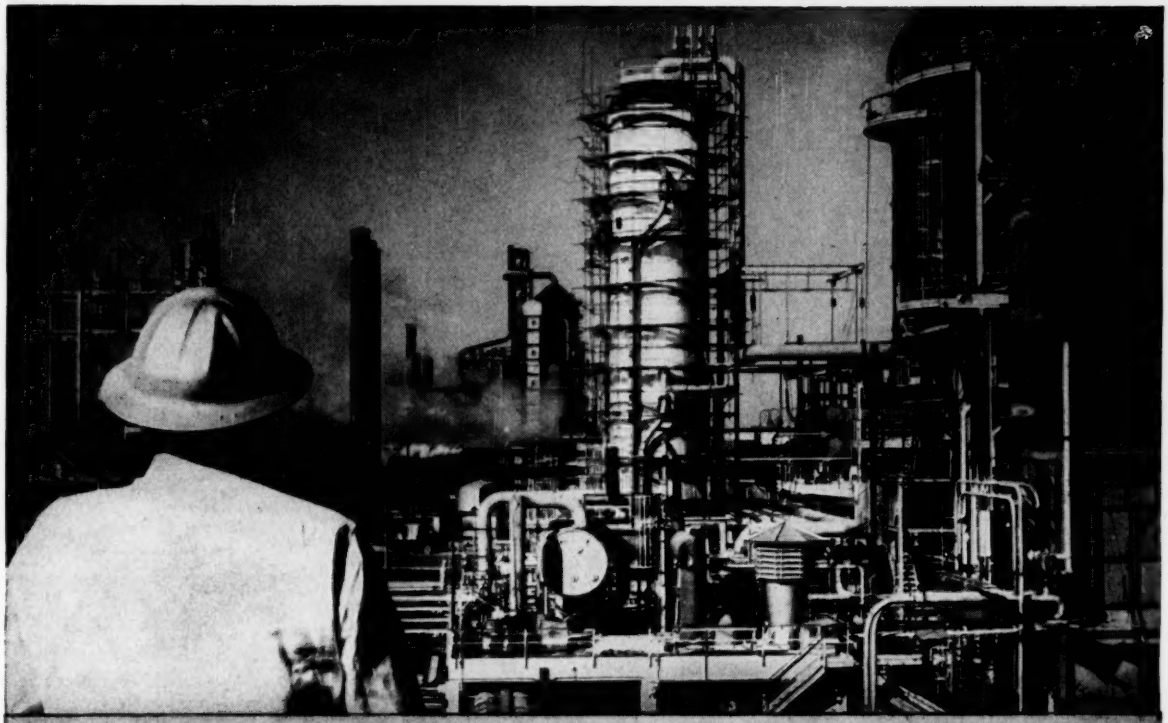
Research and development briefs

Combination of ceramic fibers and metal yields an exceptionally high strength-to-weight ratio material, declares Horizons, Inc. (Cleveland). Company is in research stage with a process that turns out fiber-reinforced metals such as 80-20 nickel-chromium alloy and alumina fiber. Problems yet to be solved include determining best fiber-metal ratios, optimum fiber dimensions, techniques for bonding and maintaining uniform fiber dispersions.

Piping liquid N_2 without insulation reportedly is possible via a new, undisclosed technique developed by Garrett Corp.'s AiResearch Manufacturing Div. (Los Angeles). Company claims it can transport liquid nitrogen upwards of 25 ft. through uninsulated flexible plastic pipe. Previously, the −320 F. liquid could not be carried more than 6 ft. without insulation

Peroxyacetyl nitrite is third pollutant—along with acrolein and formaldehyde—that's responsible for eye irritation caused by smog, University of California (Riverside) reports. Moreover, PAN, produced by photochemical reaction of nitrogen oxides, causes plant damage.

For more on DEVELOPMENTS.....78



PROBLEM: An effective solid catalyst was sought for the alkylation of isobutane with ethylene to produce diisopropyl, a high octane gasoline component valuable for its high lead susceptibility and excellent volatility.

SOLUTION: Use of BF_3 with certain hydrated salts produces active alkylation catalysts which bypass many problems encountered with known catalysts. These new catalysts can be used at low temperatures—thus avoiding undesirable side reactions and mixing problems due to changes in viscosity.

NEED A BETTER CATALYST?

INVESTIGATE B&A® *BORON TRIFLUORIDE*

The versatility of boron trifluoride and its cost-cutting advantages make it a catalyst to be considered in almost any organic synthesis problem. The use of BF_3 as an alkylation catalyst in the preparation of diisopropyl (described above) is an excellent recent example. The next synthesis problem BF_3 will help solve may well be *yours!*

Here are some of the reactions catalyzed by BF_3: polymerization, alkylation, esterification, nitration, sulfonation, halogenation, isomerization, arylation, cyclization, hydration, acylation, and there are more!

Baker & Adamson has long been the leader in BF_3 research and production. We were the first to introduce boron fluoride etherate to industry. We pioneered in shipping the compressed gas by tube trailer transport—making it readily available in large commercial quantities. Steady, dependable supply is assured when you call on B&A for boron trifluoride.

Write today—for technical data on the properties and typical uses of B&A Boron Trifluoride gas or any of its complexes listed. Attach company letterhead, please.

- Boron Trifluoride, Di-acetic Acid Complex
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- Boron Trifluoride, Ether Complex, Tech.
- Boron Trifluoride, Ethyl "Cellosolve" Complex
- Boron Trifluoride, Hexamethylene-tetramine Complex
- Boron Trifluoride, Monoethylamine Complex
- Boron Trifluoride, Monohydrate
- Boron Trifluoride, Para-cresol Complex
- Boron Trifluoride, Phenol Complex, Tech.
- Boron Trifluoride, Piperidine Complex
- Boron Trifluoride, Triethanolamine Complex
- Boron Trifluoride, Urea Complex

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SHELL-filled pit neutralizes 300 gpm. of acidic plant-waste.

Clam Shells Kill Waste Acid

Du Pont uses an open pit as reactor for neutralizing waste acid mixture with clam shells dredged locally.

Mention clam shells, and most engineers will probably bring to mind a day at the beach, a shore dinner, or, less likely, a cement plant or lime kiln. But apparently someone at Du Pont's Sabine River Works at Orange, Tex., recently conjured a different picture, seeing this marine-life residue as a handy, inexpensive alkali.

The result: a novel Sabine River neutralization unit, that lowers NaOH consumption by over 60% when the plant treats an acidic waste stream before disposing of it.

Heart of the unit, started up last year, is a simple, wood-lined pit, 36 ft. long, 5 ft. wide and 9 ft. deep. Du Pont dumps truck-delivered clam shells into the pit twice a day, feeds up to 300 gpm. of 1.5-pH waste liquid through spargers at the pit bottom.

The liquid passes upward through the shell bed, and overflows into a sump with an exit pH of 5.6. The stream then needs only token NaOH treatment to meet a specified minimum disposal pH of 6. Residual sludge doesn't significantly hinder the operation, and needs be removed only about twice a year.

▶ **Noxious Feed**—Final destination of the plant's acidic stream is a waste pond. It must be neutralized en route, mainly because in contains an organic acid notorious for its bad odor. Total acids content is 0.6%, half of which is nitric acid.

Plant formerly treated the stream with NaOH alone. However, a pilot program showed clam shells to be an attractive substitute, and Du Pont decided to design and build the present plant-scale unit.

▶ **Construction**—Creosoted timber and stainless steel bolts, nails and piping were used, to prevent rotting or acid attack. The pit was not designed watertight, because it sits in clay soil that serves as a natural barrier to seepage.

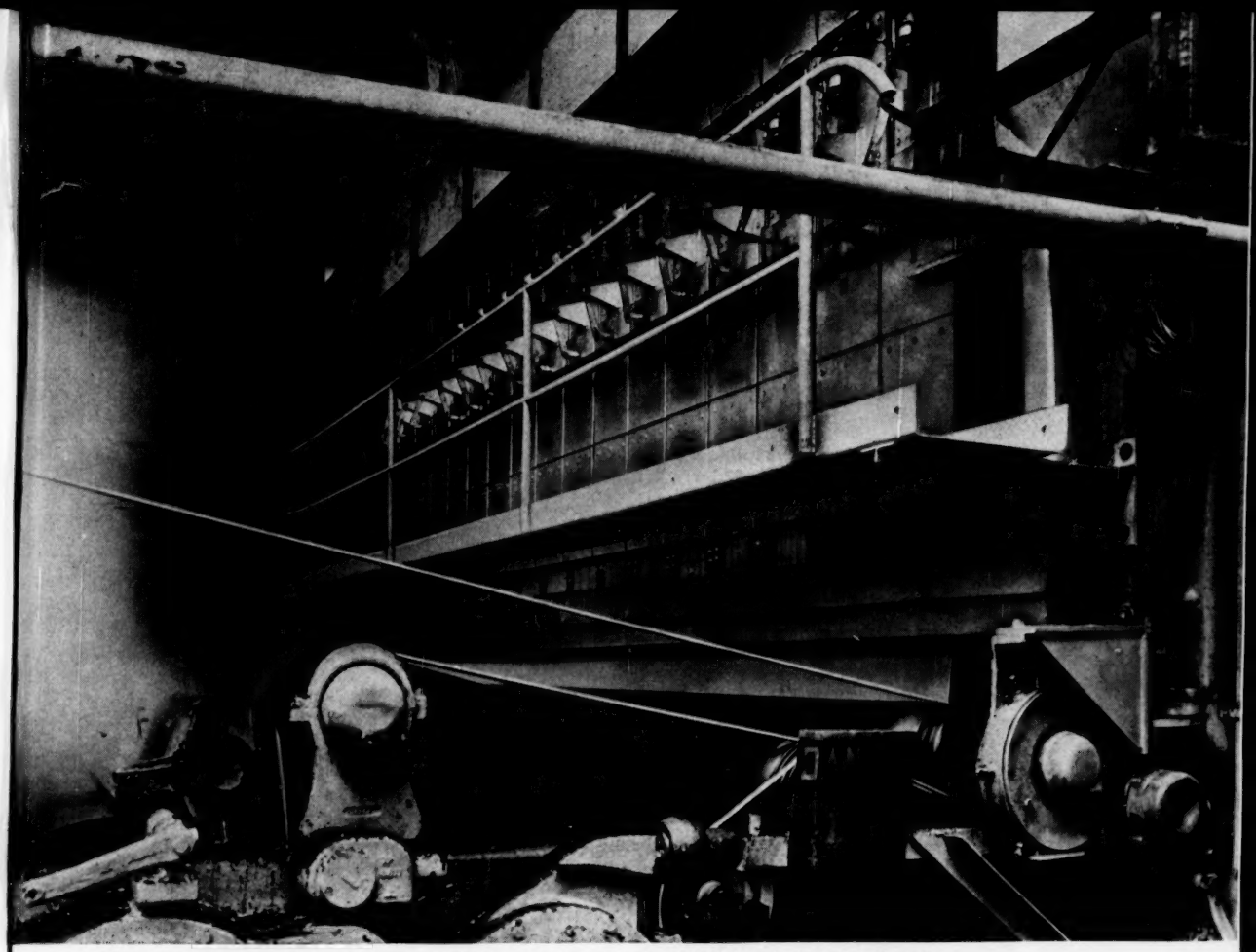
Piping joined the sump to an existing NaOH neutralization tank, where the pH would be brought up to 6. Pilot data had led engineers to expect a pit product stream having a 4.5 pH, and on the eve of startup they anticipated that the new unit would lower caustic consumption by 60%.

▶ **Betters Expectations** — The pit, designed big enough to operate over a week-end without fresh shells, provided a liquid hold-up of 55 min.—almost three times the maximum pilot plant hold-up. When operators began running the unit they found that the exit pH was consistently 5.6; thus, NaOH savings were even greater than expected. They amounted to 85% during the first four months of operation.

Du Pont plans to use the unit continuously during summers and intermittently during winters. It requires little attention from operators or maintenance forces.

Mexico Sets Up Petrochemical Reserve

Mexico's governmental oil monopoly, Pemex, now has a decree signed by President Mateos specifying 16 petrochemicals as the exclusive property of the government. Included in this "government reserve" are ethylene, polypropylene, propylene, polyethylene, dodecylbenzene, toluene, benezene, xylene, styrene, butadiene, methanol, isopropanol, ethyl chloride, ethylene dichloride, cumene and ammonia.



VIEW across paper machine shows end of dryer section fitted with high-velocity air shroud.

New Air-Handling Concept Speeds Drying

A new look is taking shape in the dryer section of paper machines as shrouded cylinders change drying mechanism.

Biggest advancement in the paper machine of the Sixties will be its reduction in length. So says the paper industry's torrent of forecasts for the new decade.

A specific forecast provides documentation: "A conventional dryer section, as we know it today, to dry 200 tons/day of fine paper at a speed of 1,500 fpm., requires 47 60-in. paper dryers. . . . In contrast, a high-velocity air-shrouded dryer section would require 16 60-in. paper dryers with air dryers shrouding them."

Number of manufacturers of these high-velocity air dryers for paper has gone from 2 to 4 in the past year. In the same period, growth in number of installed units accelerated greatly, now totals close to 100. Orders now on manufacturers' books more than double the count.

▶ **More In Same Space**—Motivation for installations to date: Expansion of existing drying capacity without increasing size of the building enclosing it.

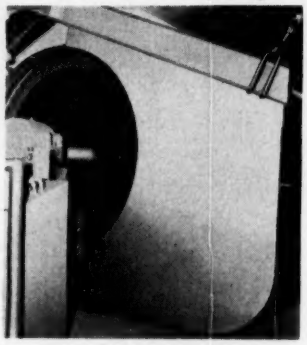
Black-Clawson—who, like Beloit Iron Works, started marketing high velocity air dryers last year—explains that one of its units does the job of three conventional cylinder dryers in a third the space. Investment cost is about 95% that of three conventional dryer cylinders.

Black-Clawson and Beloit, joined by Rice Barton Corp. and J. O. Ross Engineering, make up the quartet now manufacturing the new drying units. They all expect the dryers to make a place for themselves wherever sheets

How New Concept Simplifies Paper-Machine Drying

Basis: 200 tons/day of fine paper produced at 1,500 fpm. speed

	Conventional Dryer	High-Velocity Shrouded Dryer
Paper drying cylinders:		
Before size press	47	16
After size press	13	6
Felt rolls	180	none
Dryer felts	10	none
Felt drying cylinders	10	none
Drives	5	5 (smaller)
Steam, lb.	83,400	55,000
Horsepower	975	1,275
Building space, lineal feet	267	157
Evaporation rate, lb./hr./sq. ft.	3	20



END view of dryer cylinder shows how high-velocity air shroud designed by Rice Barton conforms closely to cylinder.

of paper are being dried via steam-heated cylinders: Primary drying of paper, drying of size press applications and aqueous coatings, the drying and setting of all types of inks, glues, etc.

▶ **Means Big Outlays** — Market for air dryers to increase capacity of existing paper machines is estimated at $25-$30 million/yr. Better than half of the air-dryer installations already made are for primary drying; all have been superimposed on existing machines.

The first installation of a new paper machine section completely designed for and equipped with air dryers is a milestone manufacturers expect to pass in the near future. It will expand market potential to about $50 million, or 1,000 units/yr.

▶ **Advantages Detailed**—Quoted early in this story as to relative lengths of a conventional dryer section vs. a completely equipped air dryer section, Rice Barton's J. W. Rohm describes a full array of the latter's advantages as follows:

"A conventional dryer section, as we know it today, to dry 200 tons/day of fine paper at a speed of 1,500 fpm., would require 47 60-in. paper dryers probably with a breaker stack and 10 felt dryers before the size press. There would be 13 paper dryers after the size press.

"On this type of machine there would be a total of 5 drives, 180 felt rolls and 10 dryer felts. There would be a very extensive steam and condensate system; a hood approximately 235 ft. long; a high-velocity air system to aerate the pockets formed by the paper and the felt, and probably a bottom-felt air system to aid in drying the felt.

"Total building space would be 267 lineal ft. from the third press to the first calender stack. The total running horsepower for the dryer section including size press, breaker stack, felt dryers, hood and auxiliary air systems would be 975. Steam consumption of the dryer section would be approximately 83,400 lb./hr.

"In contrast, a high-velocity air-shrouded dryer section for 200 tons/day of fine paper at a speed of 1,500 fpm. would require 16 60-in. paper dryers with air dryers shrouding them; again, probably a breaker stack splitting this section; a size press and 6 60-in.-dia. paper dryers shrouded by air dryers.

"There would be 5 drives which would be much smaller. No felt dryers, felt rolls or dryer felts would be required. Steam and condensate system would be relatively simple while hood and auxiliary dryer air systems would be eliminated.

"Building space from the third press to the first calender stack would total 157 lineal ft. while running horsepower including the cylinder dryers, the air dryers, the size press and the breaker stack would be 1,275.

"Steam consumption of this dryer section would be 55,000 lb./hr. If natural gas were to be available, the heat would come from 33,000 cu. ft./hr. of gas and 22,000 lb. of steam."

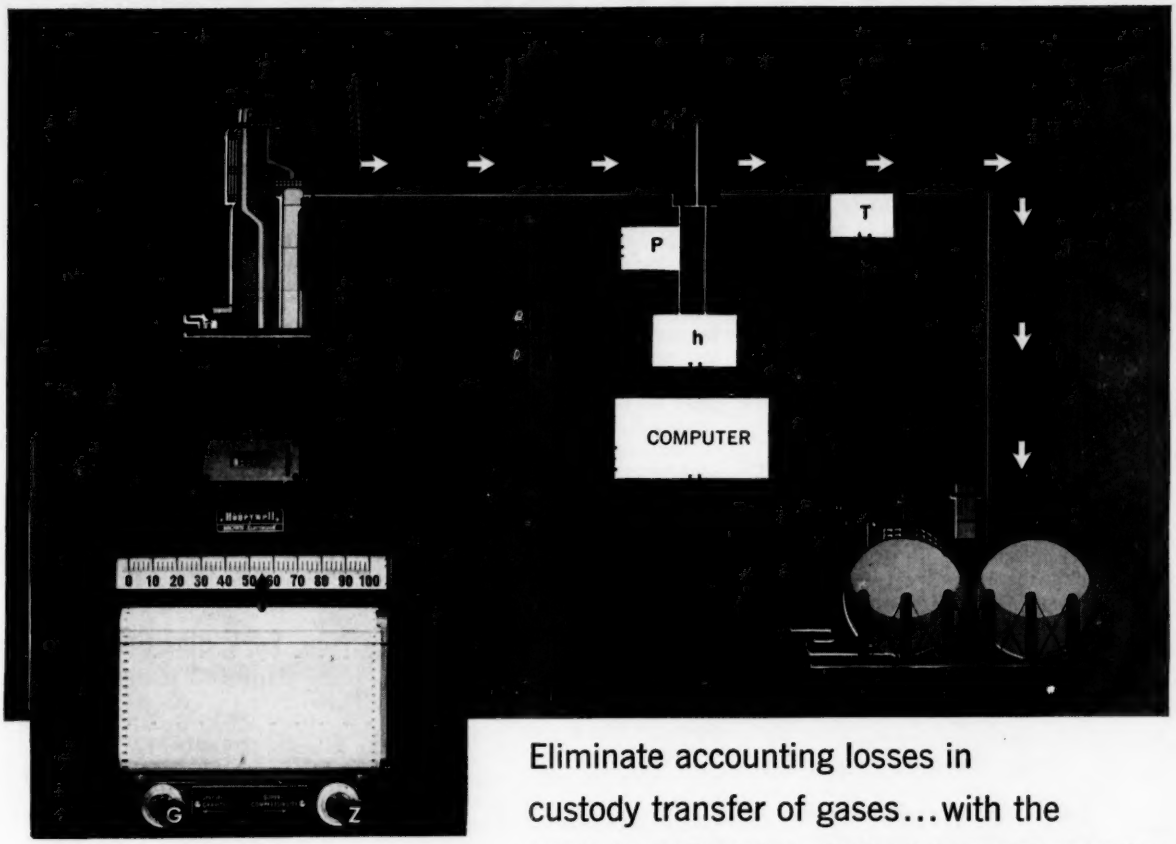
▶ **Snug Fitting Shroud**—In general, one of the new units fits close to the entire length and upper or under periphery of a conventional drying cylinder. A large number of nozzles and slots patterns its inner curvature.

Nozzles direct hot air to the paper web as it passes over the cylinder; slots recirculate or exhaust air. Recirculated air system is conventional, requires 7-10% makeup air.

▶ **Activates Boundary Layer** — The new dryers make use of the principles and concepts in fluid film theory to greatly increase the thermal conductivity and mass transfer of the boundary layer film.

When air is the sole source of heat, mass transfer takes place giving high drying rates. When heat is also supplied by a dryer roll, the high mass transfer rate produces lower surface temperatures and partial pressures than normally encountered with the roll alone, even though very high air temperatures may be used.

This causes increased heat transfer from the roll and reduces the tendency of certain



Eliminate accounting losses in custody transfer of gases...with the NEW HONEYWELL GAS FLOW COMPUTER

When you're selling or buying gas, even a slight inaccuracy in flow measurement can mean the loss of many dollars. Prevent this loss with the accurate, all-electric gas flow computer. It measures, records, and totalizes *mass rate* of gas flow, automatically and continuously. Temperature and pressure variations are compensated for automatically—eliminating the inaccuracies of "averaging" and other methods of computation.

The gas flow computer does away with tedious, time-consuming calculations and the possibility of human error. In most applications, it will perform with accuracy of $\pm 1\%$, and, under ideal conditions, with accuracy of $\pm \frac{1}{2}\%$. You can use this new computer to measure mass flow of such gases as ammonia, hydrogen, ethylene and other hydrocarbon gases, as well as hydrochloric acid gas. And you can easily link it to telemetering and remote control systems, supervisory control, data handling, and industrial process computers. Cost of the computer in most installations runs less than $4000.

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MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Control, Ltd., Toronto 17.

Here's how the Honeywell gas flow computer solves a gas flow equation:

$$Q = K\sqrt{\frac{hP}{TGZ}}$$

Where **Q** = mass rate of flow, scfh
h = differential pressure, inches of water
P = static pressure, psia
T = flowing temperature, °R, (°F + 460)
G = specific gravity
Z = super-compressibility
K = orifice flow constant

The *ElectriK Tel-O-Set* △P/I transmitter measures *h*; an absolute pressure transducer measures *P*; and a resistance thermometer bulb measures *T*. The analog computer multiplies *h* by *P* and divides by *T* . . . and sends a resultant millivoltage to the *ElectroniK* recorder. The recorder applies the correction factors *G* and *Z*, extracts the square root, and records the resultant mass flow *Q*.

75th YEAR — ENGINEERING THE FUTURE

Honeywell
First in Control
SINCE 1885

sheets to blow off the roll. Therefore, somewhat higher steam pressures may be carried in the roll.

An example of fairly typical operating conditions is provided by a three-dryer-head Black-Clawson installation on a machine making 40- to 70-lb. kraft: Evaporation rate—32-40 lb./sq. ft./hr. of water; operating temperature—660-700 F.; direct fired by gas; air velocity—16,000 fpm.; profiling control of moisture variation—± ½ of 1%. Installation was made on a weekend shutdown, increased production by up to 120 tons/day.

▶**Manufacturers Differ** — Air-dryer models vary with the manufacturer in certain features. In the Rice Barton unit, nozzles are supplied from a single chamber. System is almost a closed air-circuit containing filter, heating system, regulating dampers, a main circulating fan, and a small exhaust fan.

Exhaust air and vapor are drawn off the return line from the drying unit and the make-up air is drawn in around the periphery of the drying unit providing an effective seal.

J. O. Ross, Black-Clawson and Beloit all have models which are solid heads compartmented across their width to allow for modulation of moisture profile across the width of the web during drying. For each compartment, supply and return of air can be controlled separately.

Ross offers two additional models. One consists of individual heads that are separately curved ducts. These are installed side by side across the full width of the dryer. Each section may be hydraulically raised or lowered independently according to the requirements of the material being dried.

The other, Ross believes, may indicate the way to elimination of dryer rolls altogether. The unit is a straight-pass type whose nozzles can be designed to convey the web material by floating it on air.

To date, however, web must be subjected to some prior drying to give it cohesive strength before entering a straight-pass dryer. Existing installations have been designed for drying paper coating.

Desalination Plant Looking for New Home

Plans for a nuclear-powered sea water distillation plant at Point Loma, Calif., have run into such stiff opposition that the Department of the Interior is scouting for a new location. Construction was slated to start last month (*Chem. Eng.*, Apr. 4, p. 65) but at the time this issue goes to press the plant is still homeless.

The coup de grace was delivered by the Atomic Energy Commission's Committee on Reactor Safeguards which objected to the site because of local weather conditions. Temperature inversions in the area, which cause California's smog problem, trap large volumes of air for days. Any radioactivity released into the air by a nuclear "incident" could be held close to the ground and seriously compound the hazard for nearby San Diego.

Previously the plant had roused Navy fears that any leaks of radioactive material from the reactor would be blamed on the Navy's planned nuclear submarine base in the area.

A. L. Miller, director of saline water for the Department of the Interior, says that alternate sites at Camp Pendleton (near Oceanside) and at Port Hueneme (40 mi. north of Los Angeles) are now under consideration.

Process Spurs Shift In Naphthalene Pattern

Naphthalene and benzene, traditionally byproducts of coke oven operations, were in frantically short supply during last year's steel strike. As a result, chemical producers — especially phthalic anhydride makers—are casting about for a more stable source of supply.

Evidence: Ashland Oil & Refining is increasing capacity and speeding construction on its new Hydeal plant it announced last fall. Hydeal is the process developed by Ashland and Universal Oil Products to convert mixed refinery alkylates to naphthalene and benzene, thus putting petroleum refiners in competition with coal chemical producers (*Chem. Eng.*, Oct. 19, 1959, p. 98).

Behind Ashland's speedup on its Hydeal plant are contracts with five major chemical firms calling for a total of 60 million lb./yr. of naphthalene. Capacity of the new plant is being upped to 75 million lb./yr. naphthalene and 15 million gal./yr. benzene—a 25% increase over original plans.

On-stream date is being moved ahead to "prior to March 1961." Unit will be located at Ashland's Catlettsburg, Ky., refinery, a switch from the original Buffalo, N. Y., site to permit construction during the winter.

New York Sets Stage For Atomic Future

New York State's year-old Atomic Development Office (ADO) is setting the stage so that the state will be in a position to bid for some of the impending business in the atomic energy field.

Encouraged by the urging of youthful director of atomic developments, 42-yr. old Oliver Townsend, the State Legislature has empowered the ADO to act based on the concept that New York should "concentrate on the non-weapons part of the atomic industry, which has the largest potential for growth and which is still largely uncommitted to any particular geographical location."

At the moment, ADO is readying an all-out search for places to establish:

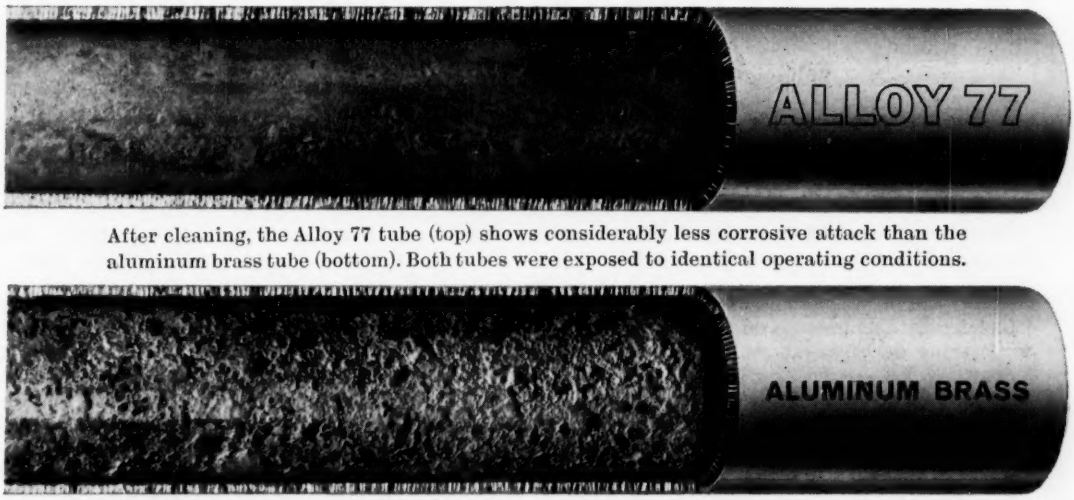
- Storage facilities for radioactive wastes, in solid form, from reprocessing of nuclear fuels. Salt beds underlying western New York will be surveyed as very likely sites to serve for this purpose.
- An atomic port at a facility on the Hudson River, Great Lakes or St. Lawrence River.
- A materials test reactor at some location such as the old Sampson Air Force Base.

Further, the ADO will carry out a 10-mo. drive throughout the state to encourage industry to use nuclear tools, based on radioisotopes.

BRIDGEPORT ANNOUNCES

ALLOY 77*

new condenser tube alloy radically reduces biofouling



After cleaning, the Alloy 77 tube (top) shows considerably less corrosive attack than the aluminum brass tube (bottom). Both tubes were exposed to identical operating conditions.

Metallurgical history is being made by Bridgeport's use of Mercury as the corrosion inhibitor in Alloy 77, the first completely new condenser-tube alloy developed in years. Startling advantages for this alloy have been uncovered during 18 years of continuous laboratory and field service tests.

Alloy 77 does what has never been done before in the control of biofouling. The Mercurial Brass Alloy kills living biorganisms before they have a chance to attach themselves to tube interiors. Costly chlorination treatments are reduced and no unusual cleaning methods are needed.

Chlorine Dollars, Cleaning Dollars, Lost Heat Transfer Efficiency Dollars can be saved when you tube or retube with Bridgeport Alloy 77. Full details can be had immediately from our Technical Data Folder. A request to Dept. **5005** for "77" will get you your copy.

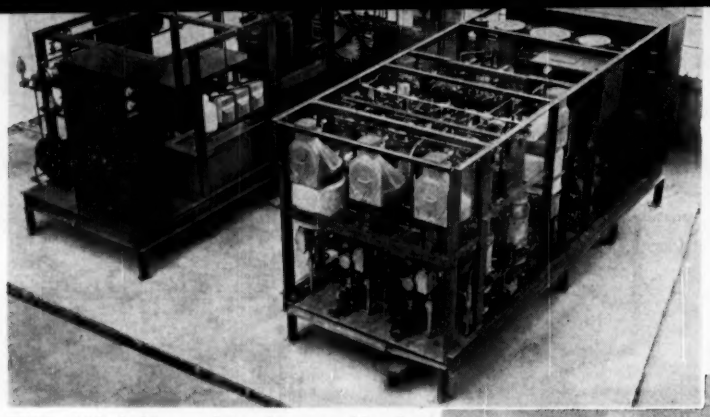
*U.S. Patent No. 2,887,374, May 19, 1959

The advantages of Alloy 77 have been proven time and again in sea water, fresh water and brackish water. Check these advantages:

1. **Radically reduced biofouling**
2. **Higher transfer efficiency**
3. **Excellent general corrosion resistance**
4. **Forms soft, thin, powdery scale**
5. **Simple, easy cleaning**
6. **Field tested performance**

BRIDGEPORT BRASS COMPANY

Bridgeport 2, Connecticut — *Specialists in Metals from Aluminum to Zirconium*



TWO skids hold complete nitrous oxide plant ready to move to location in flying boxcar.

Design Squeezes Process Into Mobile Unit

Ready to produce nitrous oxide at any location, mobile plant moves by plane, train or truck.

Design, construction and testing of a portable nitrous oxide generator for the U.S. Army Corps of Engineers has just been completed by Lummus Co. at its engineering development center, Newark, N. J.

In the form of 40 lb./hr. of liquid nitrous oxide, plant will afford field supply of anesthesia for use under combat conditions. Thus, the Army can avoid expensive, long-distance shipping of returnable cylinders of compressed gas to and from various theaters of war at a construction cost of about $250,000/generator.

Process, specified by the Army, is conventional decomposition of ammonium nitrate by heat. Ammonium nitrate can, of course, be shipped in bags, thereby eliminating return of "empties."

▶ **Fits Flying Boxcar** — Parameters, set by the Army, posed problems in selection of materials of construction, selection and positioning of equipment and instrumentation.

Dimensions were dictated by size of the rear door of a flying boxcar. The Army specified that the unit could be placed on one or two skids, but no one skid could exceed 8 ft. high or wide, nor be longer than 20 ft. Lummus's unit takes advantage of the full two-skid limit.

For portability by plane, train or truck, design had to incorporate shock and thrust resistance. And the unit had to be simple and safe enough to permit operation from a manual by soldiers.

To satisfy end use as anesthesia, process has to turn out a nitrous oxide product that meets USP purity requirements.

▶ **What Goes Where**—The train of process equipment assembled by Lummus starts with a group of ammonium nitrate melting pots followed by a group of decomposition vessels; caustic, sulfuric-acid and steel-wool scrubbers; compressor; hot KOH absorber; dessicator, liquefier and stripper.

Equipment for melting, decomposing and scrubbing is all mounted on the first skid with the balance grouped together on the second. A plastic bag bridging the two skids provides gas-surge capacity.

▶ **Light-Weight**—Decomposition pots and melters are light-weight aluminum, primarily because steel would corrode under conditions of use.

For construction of caustic, acid and steel-wool scrubbers, operated at atmospheric pressure, Lummus could turn to 80-lb./cu. ft. glass-fiber-reinforced polyester resin. Steel and lead, the alternate choices for this equipment, would have been seven or eight times heavier.

Polyethylene Tellerette packing for the caustic and acid scrubbers, rather than porcelain or saddles, saved more weight.

The plastic surge bag was designed specially for this portable generator, consists of vinyl-plastic-sheeting inner envelope and vinyl-impregnated nylon fabric outer casing.

Providing 300 cu. ft. capacity, bag weighs 30 lb., folds up into small bundle for storage. It inflates completely at only $\frac{1}{2}$-in. w.p., important because the decomposition pots should operate at atmospheric pressure.

▶ **And Rugged** — To meet requirement for a small, shock-resistant compressor, Lummus finally obtained from Corblin (Paris) a unit that compresses

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BALL VALVE

Versatile Cooper Ball Valves throttle like globe valves; handle slurries like diaphragm valves; control flow with the positive on-off operation of gate valves. Full port openings — straight through flow pattern — no turbulence. Interchangeable union ends for maximum versatility in any of the wide variety of end connections available. Valves go "on stream" in minutes. No other ball valves give you these plus features which guarantee maintenance-free operation and *eliminate costly down time.* Write for Bulletin BVF.

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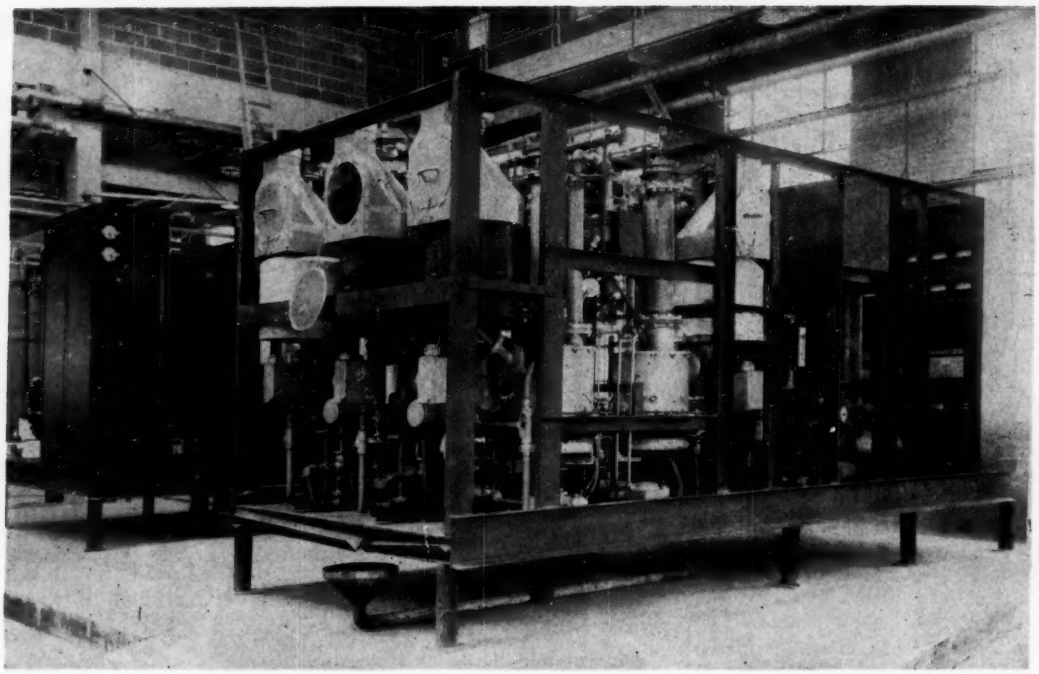


PORTABLE skid holds melters, decomposers, scrubbers and controls (l. to r.); finishing units on second skid.

gas by flexing a diaphragm with hydraulic fluid.

Finding the right package unit for N_2O liquefaction presented a problem, too, because broad military specification sets operating temperature range from 33 to 125 F. for all equipment. A good answer to this problem was choice of a 1¼-ton fluorinated hydrocarbon refrigeration unit.

Piping between decomposition pots and caustic scrubber is Carpenter 20 stainless steel to withstand acid. All other lines and all equipment beyond the steel-wool scrubber are steel.

▶**Batch Feed**—While generator turns out continuous flow of liquid N_2O at 40-lb./hr. rate, ammonium nitrate feed is introduced batchwise. Each hour, one of five melt pots is fed 100 lb. Each such charge takes five hours to decompose.

Heating of the insulated melt pots is controlled automatically to maintain melt and skin temperatures which avoid premature decomposition. Through a manually operated ram-type flush-bottom drain valve, melted charge discharges into decomposition pots.

▶**Simple, Yet Safe**—From each of the five decomposition pots, nitrous oxide vapor flows through a condenser fitted with an orifice flow meter. If flow exceeds that produced by a safe 8 to 10 lb./pot/hr. decomposition rate, heaters clamped to outside of pot shut off automatically. At a still higher flow-rate setting, water sprays on pot to stop reaction.

A pressure rise in the pot itself opens a 0.5 lb. relief valve situated at the top of a vent stack where splashes from the pot cannot reach it. If reaction does not stop fast enough, exterior of decomposition pot is flooded. Also, there is an emergency water tank stored on the skid deck.

When orifice meters detect drop in flow rate, indicating that reaction is completed, heat to pot shuts off. A thermal conductivity analyzer measures total N_2O content in product, incorporates manual probe for detecting leaks in system.

Product stream from decomposition pots goes through scrubbers mentioned previously to remove nitric acid, nitric oxide, ammonia and trace acids. Then, it flows into plastic surge bag.

▶**Final Cleanup** — The diaphragm compressor, which is two-stage water-cooled unit, raises pressure to 1,000 psig. Passage through a hot KOH tower removes last traces of impurities, leaving N_2O, N_2 and water. Standard dessicant dryer then takes out water.

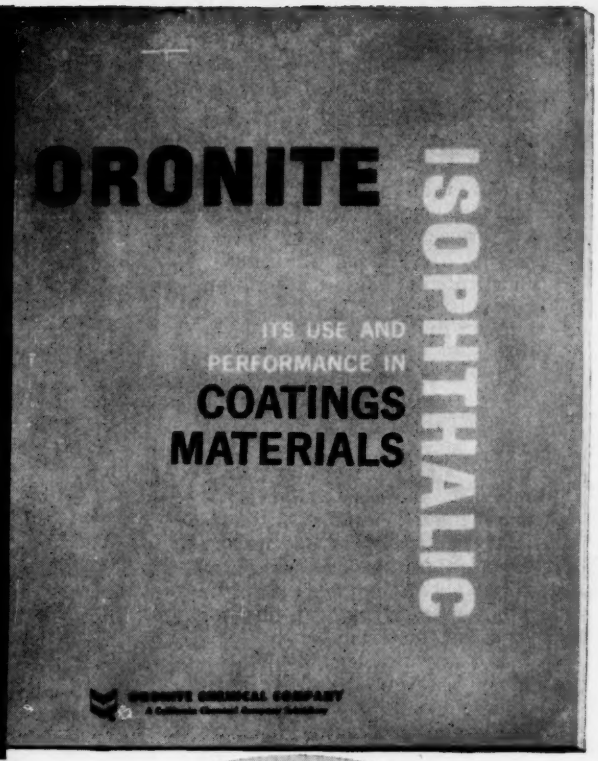
A 1¼-ton fluorinated hydrocarbon refrigerating unit liquefies the gas stream and feeds it to reboiler coil at 1,000 psig. where it boils N_2O in reboiler shell.

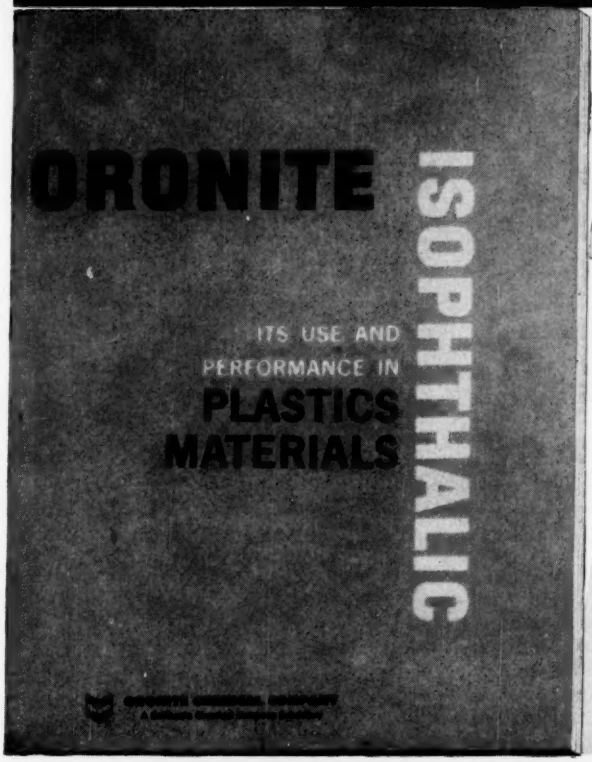
Discharging from reboiler coil, the subcooled liquid N_2O-N_2 mixture splits into two streams. One stream, containing most of the flow, passes through an expansion valve into bottom of stripper column as a vapor at 600 psig. Other stream flows into condenser on stripping column.

Stripping column operates under pressure control which vents N_2 from top of tower. Liquid N_2O condensed from N_2 before venting flows down tower against upflowing N_2O-N_2 vapor.

Product N_2O is taken from shell side of reboiler. Mixture of N_2O-N_2 vapor discharging from overhead condenser coil recycles to compressor.

Two New Isophthalic brochures by Oronite





If you are a producer or user of surface coatings or plastics products you will be interested in the use and performance of Oronite Isophthalic in these fields. Two new brochures present the latest information and test data on Isophthalic by the Company who pioneered, developed and first commercially produced this unique raw material.

You will also want to know of the technical service available to users and potential users of Oronite Isophthalic. Please address your inquiry to Oronite's executive offices and ask for the "Oronite Isophthalic plastics brochure" or the "Oronite Isophthalic surface coatings brochure." If you wish both, please request both.

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New Studies Explore Water Evaporation

More than conservation of water may be forthcoming from evaporation studies now underway by Dr. Russell G. Dressler, San Antonio water-conservation specialist.

Long-time proponent of monomolecular films to retard evaporation of water from open reservoirs, Dressler is studying the physical chemistry properties of water surfaces. Using a hook-gage with micrometer scale mounted above a container of water in the laboratory, he measures change in level and rate of evaporation under controlled simulated atmospheric conditions, with or without films or dissolved materials.

For any problem involving a given reservoir, Dressler can determine conditions of wind velocity, water surface temperature and air-wind temperature and humidity, then apply this information in the laboratory to arrive at means either for retarding or accelerating evaporation.

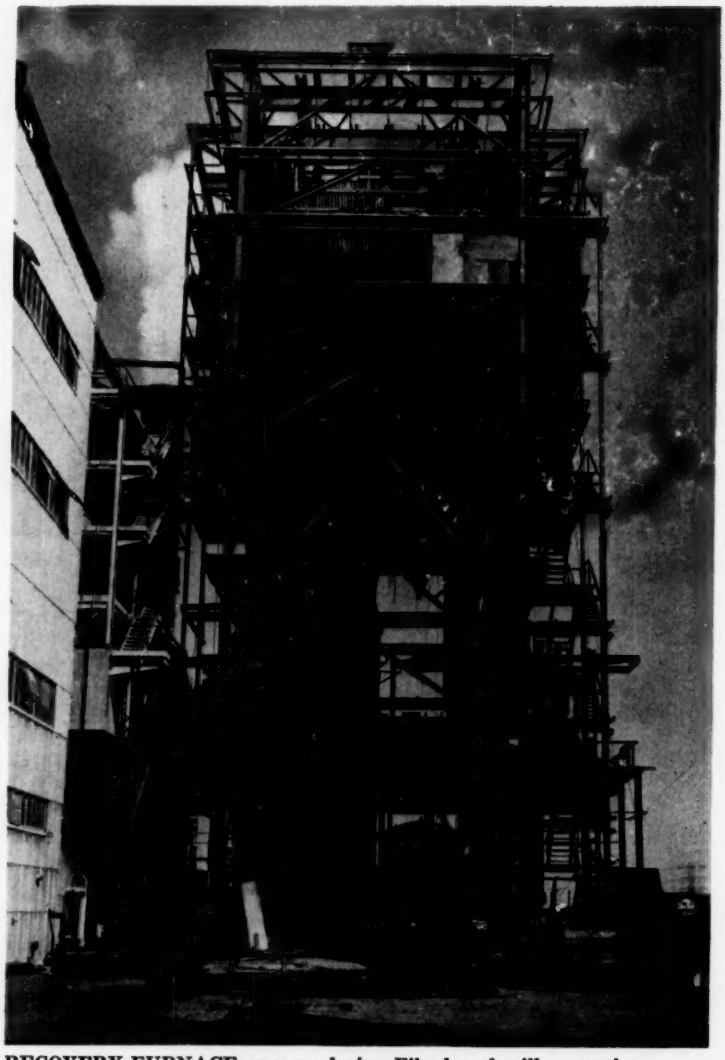
New Idea: Submersible Rubber Storage Tanks

St. Petersburg, Fla., is the site of a novel experiment in storage vessels. A team of engineers from Firestone Tire & Rubber, Jet Fuel & Storage Co. and Global Marine Exploration Co. are cooperating in a unique pilot venture to test the practicality of underwater storage tanks.

Engineers cite several reasons for taking to the water. First, it permits bulk storage of materials considered too hazardous for certain land locations. In event of nuclear attack, underwater tanks would provide an area relatively safe from radioactivity. And for cramped shoreline plant sites, it offers a way to extend storage capacity.

Firestone is supplying two 10,000-gal. collapsible tanks made of rubber-impregnated and coated fabric. Tanks will be set in special cradles anchored to the ocean's bottom, 40 to 200 ft. below the water's surface.

INDUSTRY NEWS



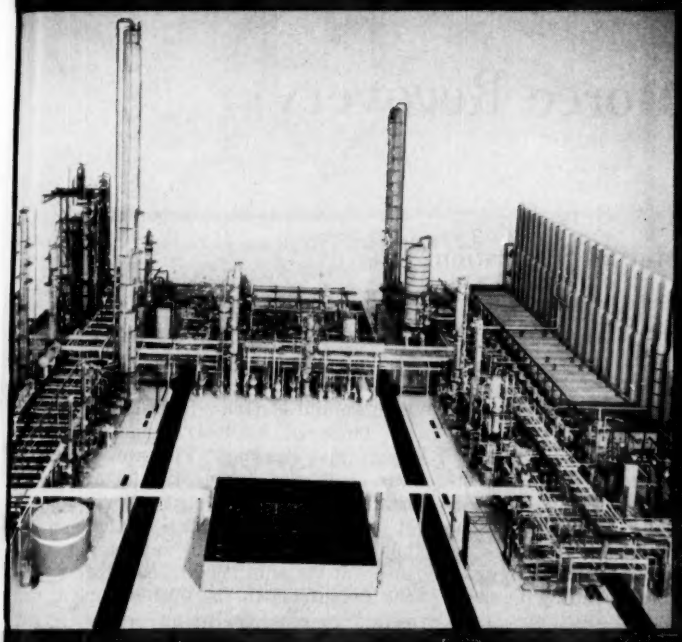
RECOVERY FURNACE goes up during Fibreboard mill expansion.

Fibreboard Paper Products Corp.'s expansion at its pulp and paperboard mill at Antioch, Calif., is over 50% complete. When the expanded plant starts operating, probably early this fall, its capacity will be over 200,000 tons/yr. of paperboard. Bechtel Corp. is handling engineering and construction for the project, which will consist of a completely new mill, independent of existing facilities. New units include a continuous digester which will process 250 air-dry tons/day of pulp, and the 400-ton recovery furnace shown above.

Sun Oil Co. will start building a $3.6-million propane deasphalter at its Toledo, Ohio,

Industry News continues on page 246.

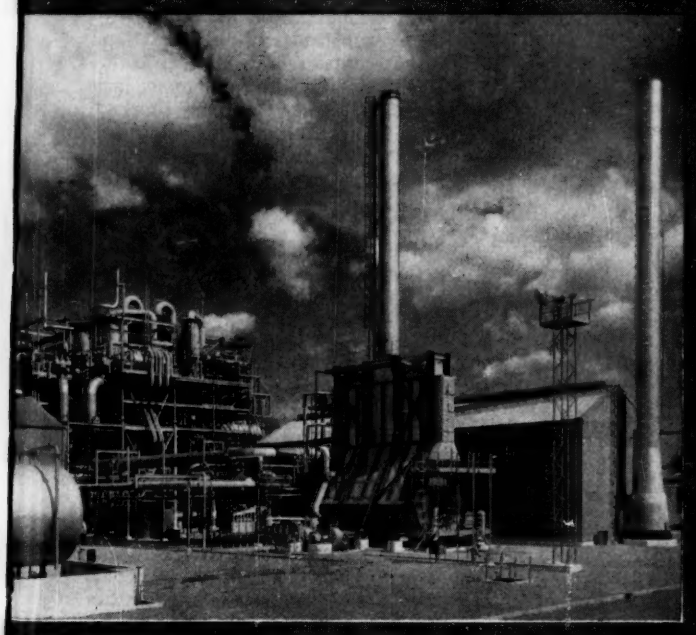
Kellogg Engineers and Builds World's Biggest Olefin Plants



Mobil

FUTURE WORLD'S LARGEST is Socony Mobil Oil Company's ethylene plant at Beaumont, Texas. It is the first large plant in the U.S. to crack naphtha into olefins. Engineered by The M. W. Kellogg Company, as shown in this scale model, it is scheduled for completion by Kellogg by 1961. Capacity will be 380 million pounds annually of 99.9% purity ethylene.

This newest plant consists of steam pyrolysis, gas treating, and product recovery sections. It has been designed to handle simultaneously both liquid and gaseous feedstocks. In addition to ethylene, major products will include propylene, propane, a B-B product, gasoline, and fuel oil.



ICI

LARGEST OUTSIDE THE U.S. is the English Wilton Works of Imperial Chemical Industries, which now includes three olefin plants. Photograph shows Plant No. 3. All are the result of close engineering cooperation between Kellogg and I.C.I. Together, they represent a current output of 110,000 tons per year of high-purity ethylene, and a potential of 140,000 tons.

Plant No. 1, commissioned in 1951, was the first full-scale adoption of the then novel process of oil pyrolysis developed in Kellogg's laboratories. Its success led to the addition of Plant No. 2 in 1956, and then to No. 3—representing a 60% increase in olefin capacity—in 1959.

Whether your approach to ethylene is through the steam pyrolysis of hydrocarbons or the recovery of ethylene from gas mixtures, Kellogg has developed processes which can assure the optimum investment, operating costs, product purity, and yield. For more information about Kellogg's 2-billion-pound background in engineering and/or building ethylene plants, write for a copy of "Olefin Plants" Kelloggram.

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Offices of other Kellogg companies are in Toronto, London, Paris, Rio de Janeiro, Caracas, Buenos Aires

CPI Spends to Reinforce Recovery

Capital spending slump, started in 1958, is all over. But most expenditures are for modernization rather than for expansion.

Alfred Litwak, McGraw-Hill Dept. of Economics

Outlays for new plants and equipment planned for 1960 by most of the chemical process industries are well above the level of 1959, and are just about back to the peak levels of 1956-1957.

In the CPI and throughout manufacturing generally, this year's capital expenditures will be largely directed toward modernization and replacement of obsolete facilities rather than expansion of facilities. As a result, relatively little capacity will be added. In fact, expected increases in sales will exceed increases in capacity planned through 1963. Excess capacity, which has been a problem for some industries in recent years, will not be aggravated by capital spending planned for 1960.

▶**Back to Peaks** — Those are some of the key findings of the 13th annual McGraw-Hill survey of business capital spending plans, just compiled. The survey was conducted during the latter half of March and early in April. It was during this period that business sentiment was supposed to be at its ebb. Yet in each of the industries in the CPI group —and in manufacturing generally—expenditures planned for 1960, as reported in the survey, are substantially higher than those reported to the McGraw-Hill department of economics last fall during a preliminary checkup of planned capital spending for 1960 (*Chem. Eng.*, Dec. 28, 1959, p. 36). Clearly, then U. S. manufacturers generally expect 1960 to be a good year for business, and they are upping capital outlays to meet current and future needs.

▶**Modernization Stressed** — Once again, capital expenditures will emphasize cost cutting and greater efficiency in production. Only in the chemical industry will a greater proportion of this year's capital expenditures go for expansion than for modernization.

As 1959 ended, most U. S. industries were operating below preferred operating rates. That, in part, is why the bulk of this year's capital spending is directed toward modernization rather than expansion.

But increases in sales anticipated for 1960 will outstrip additions to capacity during the year. And manufacturers should

Expenditures Are Back to Peak Levels

	Capital Spending (Million Dollars) Present Status		Future Plans		
	Planned 1960	% Change 1959–1960	1961	1962	1963
Chemicals	1,704	+38	1,721	1,687	1,738
Paper & Pulp	788	+25	678	556	578
Rubber	266	+40	245	198	188
Stone, Clay & Glass	695	+31	585	577	552
Petroleum Refining	787	+ 5	826	884	990
All Manufacturing	15,243	+26	14,161	13,330	13,618

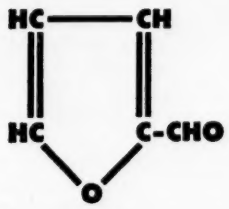
Operating Below Preferred Rates, Most Industries Are Directing the Bulk of Spending to Modernization

	Capacity Operating Rate		Capital Spending Planned for 1960	
	Preferred	Actual	Expansion	Replacement & Modernization
Chemicals	93%	82%	63%	37%
Paper & Pulp	100	91	49	51
Rubber	96	84	44	56
Stone, Clay & Glass	90	78	47	53
Petroleum Refining	97	86	9	91
All Manufacturing	94	85	35	65

A TECHNICAL MEMO FROM THE QUAKER OATS COMPANY ON

QO® FURFURAL FOR NEW PRODUCT OR NEW PROCESS DEVELOPMENT

If you are interested in product development or process improvement, take a look at QO furfural.



GENERAL PHYSICAL PROPERTIES

Boiling point (at 760 mm), °C.	161.7
Freezing point, °C.	−36.5
Refractive index (n 20/D)	1.524-7
Specific gravity, 20/20	1.161-3
Solubility in	
water (wt. % at 20°C.)	8.3
alcohol; ether	∞

FLUID PROPERTIES

Viscosity, cps. at 25°C.	1.49
at 38°C.	1.35
Surface tension, dynes/cm. at 30.0°C.	41.1
Vapor diffusion coefficient, $cm^2/sec.$	
at 25°C.	0.087

THERMODYNAMIC PROPERTIES

Heat of vaporization, $\triangle H_{433.8}$ kcal./mole	10.22
Thermal conductivity, B.T.U./(hr.)	
(sq. ft.) (°F./ft.) at 100°F.	0.1525

IDEAS TO INVESTIGATE

Want to start something new? Less than a "bit" will buy you a pound of this chemical in tank car lots and offer a mighty convenient starting point for synthesis of many intermediates. Reaction environments determine the nature of the end products—either ring types or open chain compounds are yours.

In an entirely different vein—furfural is a really useful tool for separating mixtures. Solvent separation of metal derivatives is rather readily achieved with this organic. Preliminary studies made on zinc salts and on rare-earths metals, invite a broader look into other metal recovery problems, generally.

MORE IDEAS

Solvent action on phenolic resin and surface wetting effects on minerals have led directly to use of furfural in abrasive wheels, discs and papers, also brake linings and other resin bonded articles.

And if you are interested in a recoverable solvent for reuse, furfural's stability will serve you, as it does others, even at temperatures as high as 450°F.

THE BIG IDEA

You can't do everything with furfural—it won't replace the coffee break—but you can use it a lot of ways. Take 10 minutes and exchange ideas about it with your colleagues. You'll find your exchange has proved profitable. We'll help matters along by sending our Bulletin on Physical Data on Furfural, if you'll ask for it.

For your copy of Bulletin 203-A, write to any one of the offices listed below.

The Quaker Oats Company

CHEMICALS DIVISION

The Quaker Oats Company — CHEMICALS — QO FURFURAL CHEMICALS — DIVISION

335G The Merchandise Mart, Chicago 54, Illinois

Room 535G, 120 Wall St., New York 5, N. Y.

Room 435G, 48 S.E. Hawthorne Blvd., Portland 14, Oregon

In the United Kingdom:
Imperial Chemical Industries, Ltd., London, England

In Europe:
Quaker Oats-Graanproducten N. V., Rotterdam, The Netherlands;
Quaker Oats (France) S. A., 3, Rue Pillet-Will, Paris IX, France;
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be closer to preferred operating rates as 1960 ends.

▶ **New Products Swell Sales**—Research and development expenditures of recent years will definitely affect the long-range sales prospects of major manufacturers. Manufacturing companies on the average expect that 12% of their 1963 sales will be in new products—products that were not produced in 1959.

Companies in the chemical industry plan to get more than an average share of 1963 revenues from sales of new products—14% of sales by such companies in 1963 will be in new products. Other industries in the CPI group are not counting on new products to bring in as great a share of their 1963 revenues. But all report that new products will be a considerable factor in their 1963 sales volume.

▶ **Research Swells New Products**—Continuing the trend of recent years, U. S. industry generally will be stepping up expenditures for research and development in the years immediately ahead. In addition to expenditures for R&D project work, chemical companies this year plan to spend $119 million for research facilities, substantially more than any other industry plans for this purpose.

The survey illustrates why research and development is important not only to those companies performing it, but to business generally—namely, because new products create demand for the products of other industries. This year, for example, almost a third of the manufacturing companies reporting in the survey indicated that a significant portion of their capital expenditures for 1960 would go for facilities—building and machinery—to make new products. And new products should continue to be a healthy stimulant to such investment in the years ahead.

New products are, in fact, a key determinant of research and development expenditures. Almost half of all manufacturing companies gear their R&D expenditures to plans for new products. Among chemical companies specifically, 42% base their R&D outlays on plans for new products, while only 29% link them to sales. Even a smaller proportion of companies in the chemical industry make profits the key factor in setting up R&D spending plans. For the CPI group, only clay, stone and glass producers weigh sales more heavily than plans for new products in planning R&D expenditures.

▶ **Depreciation** — Supporting higher planned capital expenditures of U. S. industry will be a growing fund of depreciation reserves. Manufacturing companies as a whole expect depreciation allowances to rise from the $7.8 billion level of 1959 to more than $9 billion in 1963. At that level these internally generated funds will be supplying a large portion of the total amount required to finance capital expenditures in the future. More than 80% of the manufacturing firms reporting in the survey indicated that it is their policy to spend all their depreciation allowance for new plant and equipment. Thus, depreciation funds will play an important role in bringing U. S. producing facilities up to date. All industries in the CPI group expect depreciation allowances to increase substantially by 1963. And all indicate that these growing allowances will be spent for new facilities. Thus there are definite indications that chemical processing industries will be able to continue their war on obsolescence.

Sales Increases Are Expected to Exceed Increases in Capacity

	Sales Increase (Physical Vol.)		Capacity Increase Index of Indust. Cap. (Dec. 1950 = 100)		
	59–60	60–63	58–59	59–60	60–63
Chemicals	9%	21%	5%	5%	16%
Paper & Pulp	8	17	6	3	8
Rubber	7	16	7	5	10
Stone, Clay & Glass	6	18	4	6	13
Petroleum Refining	4	10	2	1	3
All Manufacturing	8	17	4	5	12

New Products Rate High in Sales Forecasts

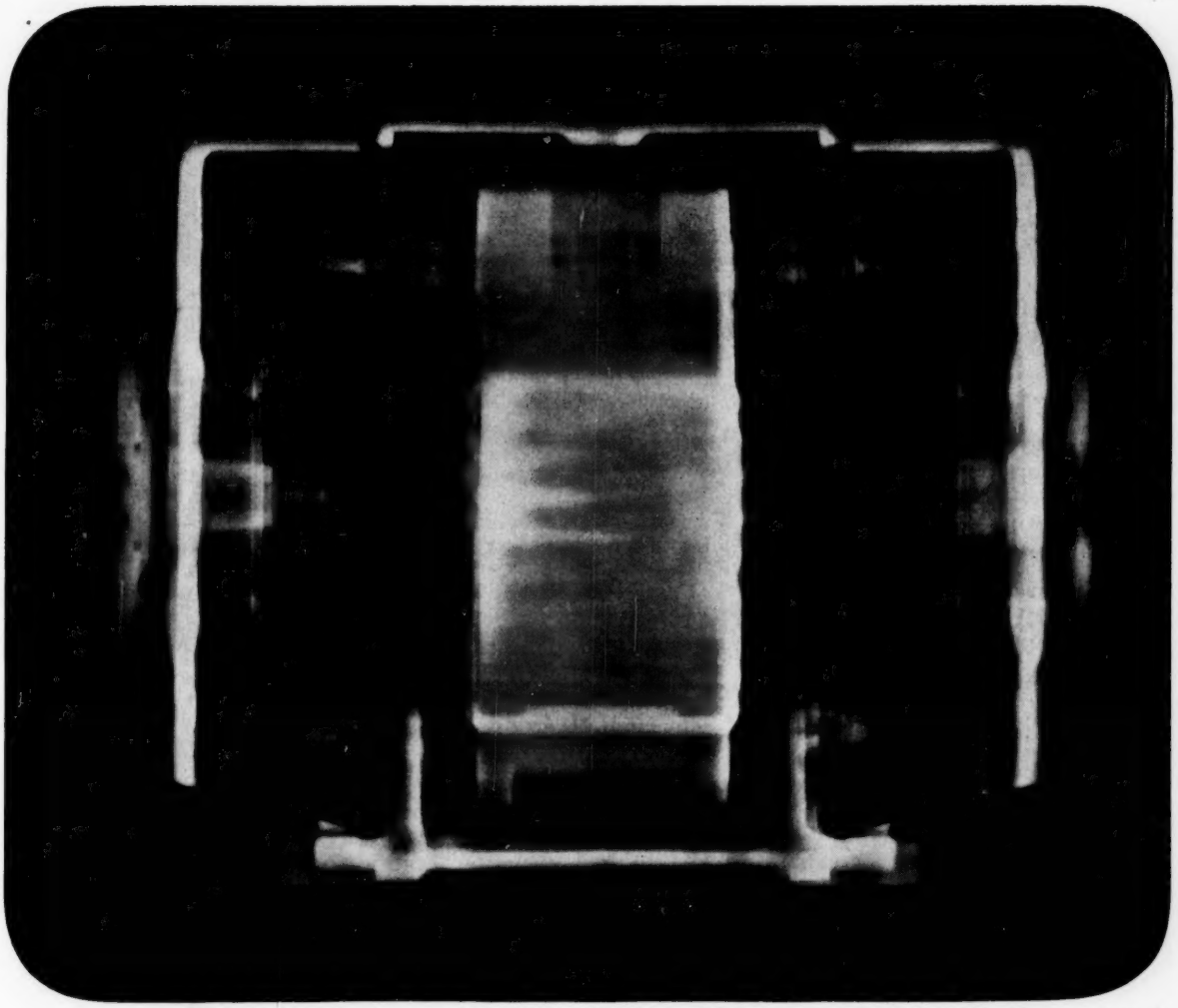
	New Products Percent of '63 Sales
Chemicals	14
Paper & Pulp	8
Rubber	7
Stone, Clay & Glass	9
Petrol. & Coal Products	4
All Manufacturing	12

R&D Expenditures Will Be Stepped Up, Continuing the Trend of Recent Years

	Research & Development Expenditures (Million Dollars)			
	Project Work			New Facilities
	Actual	Planned		
	1959	1960	1963	1960
Chemicals & Allied Products	661.8	714.7	850.5	119
Paper & Allied Products	63.4	76.7	95.9	24
Rubber Products	89.3	95.6	111.9	5
Stone, Clay & Glass	73.6	83.9	104.9	30
Petroleum Products	300.7	315.7	347.3	28
All Manufacturing	9,027.0	9,554.6	10,711.9	682

ALLIS-CHALMERS

A-1337



Actual radiograph of a 5-hp open-type motor taken with a 24-million volt Allis-Chalmers Betatron.

X-ray view of motor health

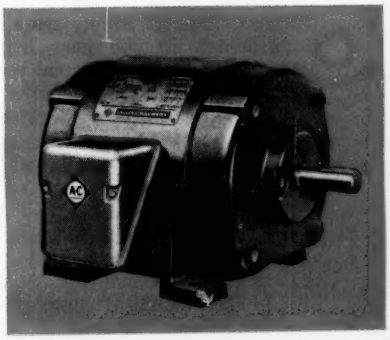
Invisible standards of perfection increase life expectancy of every Allis-Chalmers motor

The exceptionally long performance of A-C open motors proves the value of thinking *beyond* established standards of design . . . of taking "significant new achievement" as the ideal.

This ideal led to many refinements for A-C open motors: double-shielded bearings that keep dirt out and allow controlled migration of grease, permanently numbered lead spacer and leads for easy identification and connection, and heavy-duty cast iron frames that resist corrosion and keep rotating parts perfectly aligned.

For totally-enclosed, open-type and *Super-Seal* general purpose motors, and electrically or mechanically modified definite-purpose motors, choose the motor built to invisible standards of perfection. Choose A-C. Special application help available.

Call your nearby A-C representative. Or write **Allis-Chalmers,** *Industrial Equipment Division, Milwaukee 1, Wis.* Super-Seal is an Allis-Chalmers trademark.



Economy Warms to Chemurgy

After imposing 25 yr. of adversity, the economic climate now puts a bloom on chemurgy promising a profitable harvest of fine organic chemicals.

Richard P. Windisch, W. E. Burnet & Co., New York, N. Y.

Surpluses and lower prices are attracting processors to take a good look at natural products as sources of fine organic chemicals.

Postwar mechanization and intensified farming, with their consequent reduction in the labor factor, have not only reduced the costs of production of many natural products, but have even reduced their cost in relation to the cost of many manufactured and mined products. The current gap opening up between the price indices of agricultural and industrial products indicates better opportunities for profit by using more farm products in industry.

Of the low cost materials, sugars and fats seem particularly promising while meat products and vegetable proteins are opening up unusual supplies of interesting chemical raw materials. Raw sugar available as low as 3¢/lb. (in the international market) and tallow at 5¢/lb. could conceivably be the basis for tonnage chemicals.

Their price now approaches that of many petrochemical intermediates, and their chemistry is equally interesting. These fields have not yet been intensely researched in proportion to their potentialities. Competing synthetic petrochemical products will no longer enjoy their cost advantages if our government tries to maintain for petroleum the same kind of supply restrictions which in the past have priced so many agricultural materials out of industrial outlets.

Coal tar and hydrocarbon chemical surpluses each sparked a research effort which ultimately gave the world a long series of new products, and it would now seem as though our agricultural surpluses could do the same for biochemicals. Such broad-based chemical companies as Du Pont, Dow, Hercules and Monsanto have already shown definite indications of an awareness of the latent possibilities in natural raw materials. Food and pharmaceutical companies are also showing a decided interest in annexing biochemical specialties, e.g., Pfizer, Merck, Armour, General Mills, Archer-Daniels-Midland, Quaker Oats, Upjohn, Miles Laboratories and Central Soya. Smaller companies in specialized fields pursuing these opportunities: Atlas Powder, Rohm & Haas, Emery Industries, Nopco and Stepan.

▶ **Molecular Complexity**—While increased tonnages of low cost consumer products and intermediates may still be expected from petrochemicals, the whole chemical frontier is advancing into areas of highly complex molecules capable of more specific and discriminating reactions. These already function in such fields as nutrition, medicine, pesticides and as additives, conditioners, flavors and colors.

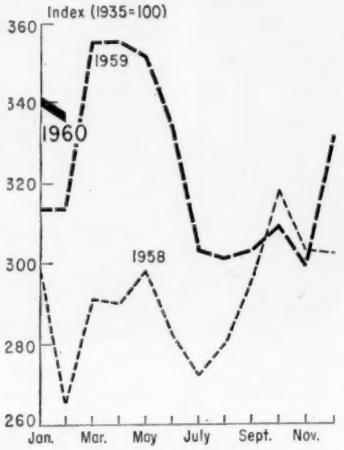
▶ **Food Laws**—With the greater use of chemicals which come in direct contact with animal and vegetable life, it is likely that materials more compatible with nature will be required, and these are more likely to stem from natural sources. Recent rulings of the FDA indicate a forced trend in this direction.

Low-cost petrochemicals, unless it be through the ammonia route, will probably never have a big place in the animal food and human nutrition areas—two places which are very important because of growing population trends here and abroad.

▶ **Better Tools**—Some of the advanced techniques developed by modern research have opened up methods of separating, purifying and reacting the more complex molecules and mixtures found in nature: Gas chromatography, high vacuum and low temperature distillation, deep fermentation, ion exchange and improved catalysts (enzymes). The use of radioisotopes is explaining many hitherto unknown natural processes.

▶ **Commodity Hedging** — Inventory losses, formerly a hazard to processors of agricultural products, are now minimized by commodity hedging and LIFO accounting. However, they have not been completely eliminated and in a deflationary economy inventory shrinkage would have to be reckoned. Chemicals made from agricultural products could never hope for the price stability enjoyed by organics derived from petroleum and coal tar. To offset this, however, in peace time they should enjoy highly abundant sources of raw materials.

Chemical Consumption

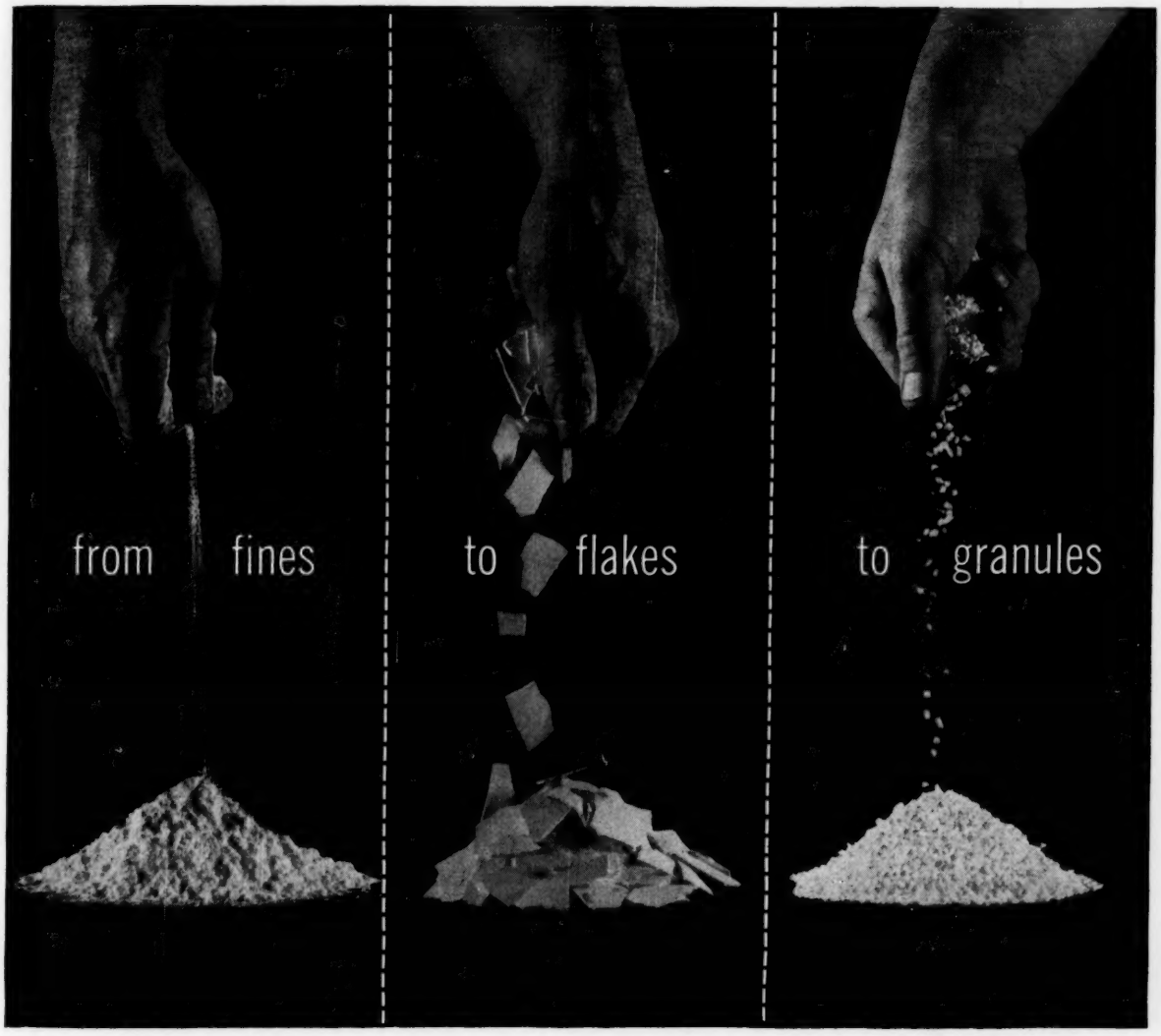


Consumption by Industries

	Jan. (Final)	Feb. (Est.)
Coal products	10.3	9.5
Explosives	10.0	10.5
Fertilizer	79.9	80.9
Glass	27.6	28.5
Iron & steel	22.1	20.4
Leather	4.2	4.3
Paint & varnish	31.3	31.4
Petroleum refining	32.9	30.4
Plastics	35.8	35.5
Pulp & paper	41.5	41.2
Rayon	26.9	24.7
Rubber	7.9	7.7
Textiles	10.5	10.4
Total	**340.9**	**335.4**

ALLIS-CHALMERS

A-1334



Consistently better product

with this profit-making continuous mechanical compacting process

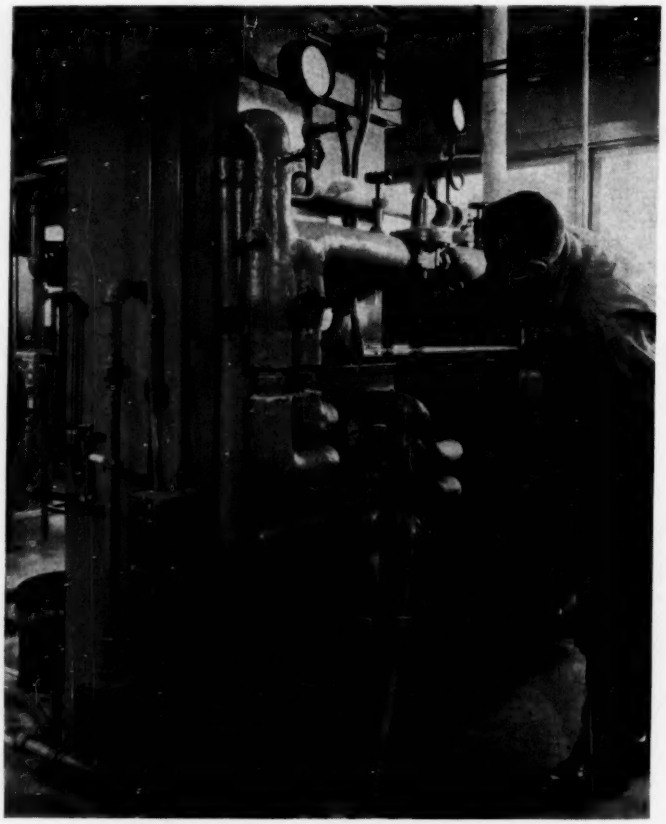
Quality control? Production control? New granular product development? Marketing or sales? If any or all of these are your responsibility, you'll want the advantages you can get with the Allis-Chalmers compacting process.

Real sales advantages are yours because the eye-appealing, uniform size granules produced by this process flow freely, have controlled solubility and will not abrade or fracture in handling.

Allis-Chalmers gives you production economies, too. The compacting process is a simplified, continuous operation. It requires less equipment, less power and lower capital investment than other, less efficient agglomeration methods.

Perhaps the continuous compacting process is the answer to your production or profit problems, too. Contact your A-C representative or write **Allis-Chalmers,** *Industrial Equipment Division, Milwaukee 1, Wis.*

CHEMICAL PRODUCTS EDITED BY N. P. CHOPEY



Solvent's Reclamation Promotes Repeated Use

Standard distillation units such as the one shown above can reclaim Chlorothene NU, a new cold-cleaning solvent.

The greater resistance of Chlorothene NU (an improved version of Chlorothene) to decomposition makes reclamation easier, without the need of either stainless steel or Heresite-lined equipment. This money-saving feature drastically increases, for large users, the solvent's usefulness in industrial cold cleaning.

Recoverability of Chlorothene NU puts it on a comparable cost basis with common solvents.

The new solvent quickly and thoroughly removes greases, oils, tars, waxes and other lubricating compounds often found on metal parts, electrical equipment and certain plastics. Features include ease of use—by dip, bucket, spray or wipe methods—greater safety and low corrosion.

Chlorothene NU will be marketed in green and white color-coded drums so that it can be quickly distinguished from solvents with other characteristics. —Dow Chemical Co., Midland, Mich. 96A

Cellophane

New type seals at low temperature, speeds wrapping.

Cellophane, the old standard in the ever-growing packaging field, has added a new member to its family.

Known as New MSD-60, the new cellophane has been engineered to provide strong heat seals at 250 F.—at least fifty degrees lower than have been possible with other cellophanes. Yet the film retains the good appearance, protection and nonblocking properties that were characteristic of the former MSD-60, a high-yield cellophane introduced two years ago.

Lower-temperature sealing means that the film needs less time in contact with heater plates to reach an effective sealing temperature. The result: new efficiencies, trouble-free production, lower costs.

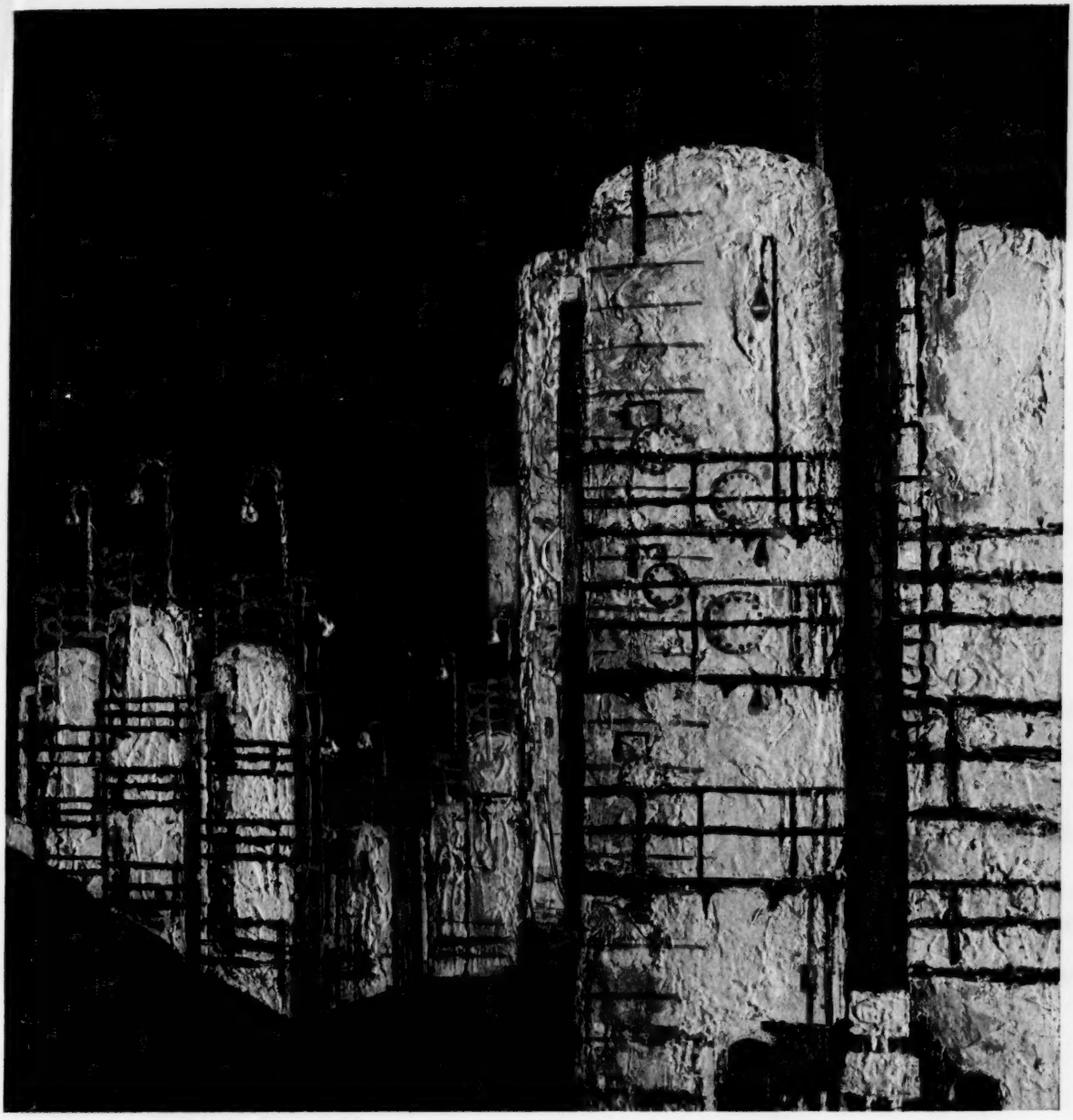
In addition to the same good appearance and protective qualities that characterized former MSD-60, the new film also features low cost due to its yield of 21,000 sq. in. per lb. Like its forerunner, New MSD-60 is readily printable.

Manufacture of the new cellophane was started several months ago, and full-scale production by all five DuPont cellophane plants will soon be under way.—E. I. du Pont de Nemours & Co., Wilmington, Del. 96B

Waterproofing Resin

Answer to rosin shortage in paper industry.

WETstrez P-685, while improving water resistance and ink penetration of hard-sized paper, also enables paper mills



More drying per dollar in nine towers showed Columbia Gulf Transmission why it pays to

mix imagination with Alcoa Aluminas

Nearly ½-million lbs of Alcoa® Activated Alumina is giving Columbia Gulf Transmission Co. maximum drying capacity per dollar in one of the world's largest natural gas drying operations. Used in nine towers at the company's Rayne, Louisiana, compressor station, the activated alumina dries 690 MMSCF of natural gas per day. Average water content of gas entering the towers is 5-6 lbs water/MMSCF. Water content of the effluent gas is below ½ lb water/MMSCF. Each tower is on stream for 24 hours with a reactivation time of 6 hours. Columbia Gulf Transmission has found that no other desiccant can furnish such efficient drying at such low cost.

When effective, economical drying is your aim, it pays to mix imagination with Alcoa Activated Aluminas—the oldest commercial desiccant available and still the most efficient. For detailed data, send for a free copy of the Alcoa White Data Sheets and a comprehensive Gas and Liquid Dehydration Questionnaire. Aluminum Company of America, Chemicals Division, 706-F Alcoa Building, Pittsburgh 19, Pa.

ALCOA CHEMICALS
ALUMINUM COMPANY OF AMERICA

For finer products . . . let Alcoa add new dimension to your creative thinking!

to reduce the amount of rosin used by 40-50%.

The material is a modified acid-curing urea-formaldehyde resin for waterproofing starch-clay coating colors and adhesives. It may solve the paper industry's problem of weak water resistance when starch coatings are applied at the size press. Corrugated container pastes are also rendered waterproof by use of P-685.

Mills which have been using the new resin for several months have substantially reduced their rosin requirements. Savings in rosin cost average $3-4/ton paper produced. Cost of P-685 averages $1/ton.—**Reichhold Chemicals, Inc., White Plains, N. Y.** 96C

Inhibitive Primer

Prevents surface contamination, undercutting.

The new specialty cold-applied inhibitive primer, Bitumastic 11-S, serves a dual role. As a shop primer it prevents contaminants from attacking surfaces before protective coatings can be applied. And, it prevents undercutting when mechanical damage produces breaks in the protective coating after it is applied.

The above photo shows results of using 11-S. The entire panel was coated with the new primer, and the right half was then immersed in artificial sea water at 140 F. for 30 days. Corrosion shows only along the score mark, and when this stain is scraped away no undercutting can be seen.

Added to its two-fold use is another possibility for 11-S, stemming from good test results even when the surface preparation of the metal is less than ideal. Though no claim is made that it will penetrate heavy rust, 11-S has been successful in passivating metal and preventing further development of rust tubercles—**Koppers Co., Inc., Pittsburgh.** 98A

Stabilizer-Dispersant

Prevents fouling in refinery process equipment.

With proper application, Nalco 262 is said to reduce or eliminate potential deposit-forming materials that foul heat exchangers, furnaces, reboilers and distillation columns.

The amber-colored, hydrocarbon-soluble additive is injected into naphtha and gas oil streams ahead of the point where fouling occurs. Its stabilizing action minimizes polymer formation, while its dispersant action prevents sludge build-up on equipment surfaces.

Equipment fouling has become increasingly acute with the advent of catalytic desulfurization and reforming units. (Industry catalytic desulfurization of naphtha and gas oil has been estimated at 2 million bbl./day.) Run lengths of a few months in these units aren't uncommon, compared with normal turnarounds of more than six months to a year in other types of processing equipment.

Field tests show that Nalco 262 solved up to 90% of refinery equipment fouling problems. In one case, a refinery faced with shutdown every month to clean a furnace, upstream from a desulfurizer, has now been without downtime due to furnace fouling for better than a year. For the refiner, 262's use resulted in considerable savings in downtime, labor costs, heat losses, while throughput increased.—**Nalco Chemical Co., Chicago.** 98B

Cross-Linked Resins

Recommended for nonwovens, industrial fabrics.

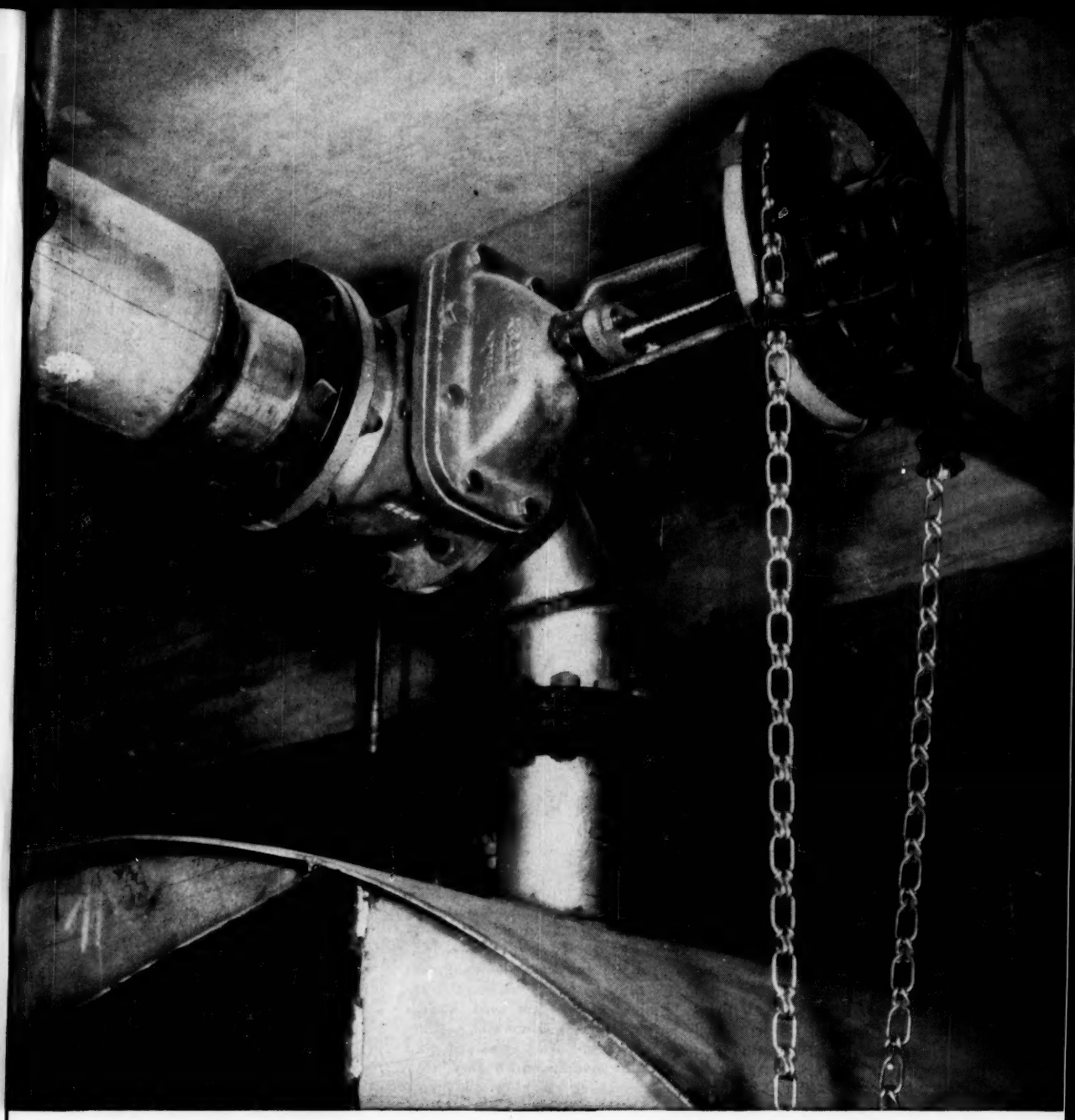
A new concept in textile finishing, involving chemical cross-linking of vinyl copolymers with thermosetting resins, has resulted in development of two new resin materials. They are designed for use with wash-and-wear, nonwoven dress goods and industrial fabrics.

Known as Resyns 78-3143 and 78-3147, these products have been specially formulated for

Newsworthy Chemicals

	Page Number is also Reader Service Code Number
Cold-cleaning solvent reclaimable by distillation.....	96A
Cellophane seals at 50 degrees lower than predecessors	96B
Waterproofing resin cuts paper mills' rosin needs.....	96C
Inhibitive primer shields metal surfaces.....	98A
Stabilizer-dispersant cuts refinery fouling.....	98B
Cross-linked resins promise quality textile finishes.....	98C
Glass pillows, balls find varied industrial uses.....	100A
Teflon-based lubricant drastically cuts friction.....	100B
Polypropylene fiber and tow available in three deniers..	100C
Polypropylene fiber ready for textile use overseas.....	100D
High-density polyethylene joins Tenite family.....	100E

For more details, use Reader Service Card



FILM GUARDIAN AT WORK... Eastman Kodak takes no chances on contamination at 1,000 acre Kodak Park in Rochester, N. Y. The 7-year-old Aloyco Stainless Steel Valve (above) helps eliminate danger from rust or contamination that could easily spoil the film base, which is later coated with a sensitive photographic emulsion. Today, thousands of industrial processes are being safeguarded by Aloyco corrosion resistant valves. Want specific examples in your field? Our engineers will be glad to help. Just write Alloy Steel Products Company, Inc., 1301 West Elizabeth Avenue, Linden, N. J. O.1

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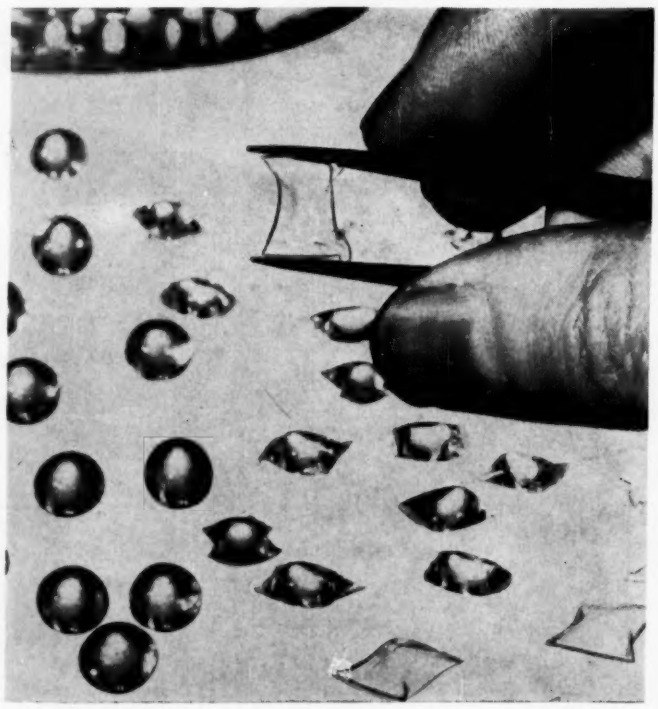


Pillows and Balls Serve as Low-Cost Fillers

Tiny glass pillows and balls—easily and inexpensively formed—are now being produced by Corning Glass for filler, packing, filtering and tumbling uses.

The pillows, both solid and hollow, are made in lengths up to ½ in. Solid pillows are used in chemical processing as fillers in refractionating columns and filter beds. And, their tumbling action provides necessary agitation in electroplating operations.

Hollow pillows provide a low-density filler material for such applications as packing in aircraft wings, where glass gives both structural support and buoyancy. They also can be used in the casting of larger plastic pieces.

Balls can be made to diameters of ½ in. In commercial application they are used in anti-lint filters of automatic washing machines. They pick up lint which is then backflushed, thus preventing clogging and stoppages.—Corning Glass Works, Corning, N. Y. 100A

finishing, hand building or pigment binding under the new cross-linking concept.

Cross-linking resins differ from ordinary polyvinyl acetate emulsions, as the structure of these copolymers makes them highly reactive with other finishers and binders. When, for example, they are reacted with formaldehyde-containing thermoset resins, extremely strong chemical bonds are formed.

Finishes produced from such reactions impart outstanding durability to fabrics, high resistance to water and cleaning solvents, fuller hand and drape, and increased strength.

Resyn 78-3143 has outstanding properties for use in finishing fabrics that require stiffness as well as wash and dry-clean resistance. Resyn 78-3147, an extremely soft resin, is suggested for finishes that are soft and flexible. It may also be used as a binder for printing on white or metallic pigments.—**National Starch & Chemical Corp., New York. 98C**

BRIEFS

Teflon-based lubricant makes wood, metal or ceramic surfaces slide smoothly and easily, prevents sticking and guards against galling and wear. Teflon resin makes possible a starting friction less than that of any other sliding surface. Coefficients of friction as low as 0.04 are common.—**R & R Co., Park Forest, Ill. 100B**

Polypropylene fiber and tow are now being offered in limited quantities. Fibers, tradenamed Prolene, are available in 2, 3 and 6 deniers at 90¢/lb. Other deniers will be forthcoming. — **Industrial Rayon Corp., Cleveland. 100C**

Polypropylene fiber, lightweight and strong, has been introduced for textile use. Called Merkalon, low-cost fiber will be used alone or in combination with wool, cotton, silk.—**Montecatini, Milan, Italy. 100D**

High-density polyethylene has been added to the line of Tenite polyethylenes. New material has densities of 0.941 and higher.—**Eastman Chemical Products, Inc., New York. 100E**

For More Information

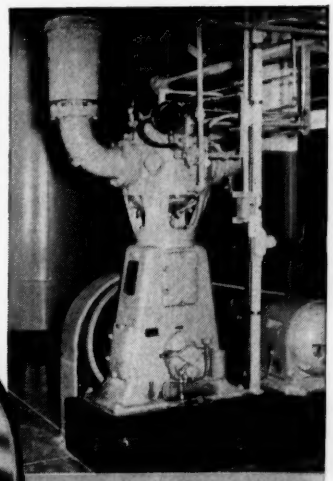
about any item in this department, circle its code number on the

Reader Service

postcard (p. 273)

Joy Design Means:

CHROME-PLATED CYLINDER WALLS FOR CORROSION RESISTANCE



Joy WGO-9 Compressors supply instrument air in southwestern power station.

Chrome-plated cylinder walls give Joy Oil-Free Compressors longer service life and lower maintenance costs. The intermittant duty typical of oil-free compressor service makes rusting of the cylinders a prime source of trouble. Because of the exclusive replaceable cylinder liner construction, Joy is able to put a chrome face on the cylinder wall which will resist corrosion and also give extra wear. This feature and the exclusive T-Block carbon-graphite compression ring construction make Joy Oil-Free Compressors economical to operate.

Joy can supply positive displacement machines with capacities up to 7392 CFM and dynamic machines in any size desired. For complete details on how to get truly low cost, oil-free air, consult your Joy representative, or write for Bulletin 926-11.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY

JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

OPEN hold-down clamps, lift cover—and screen is available for cleaning.

Fast Action for Fast Screening

One end of screen moves in circle, other end in ellipse; particles enter screen openings from different angles.

Cirlyptic sounds enough like calypso to suggest native rhythms and frenzied dance movements. With Cirlyptic sifters, the screen has the rhythm and the feed particles are in frenzied motion. Result: high throughput and good screen efficiency.

Screen movement results from two superimposed types of agitation. The lead end of the screen is driven with a circular motion; the other end, rocking back and forth, forms an elliptical pattern. The combination of the two movements gives the sifter its name.

Previously, Cirlyptic screens were principally used to screen flour and dry milk solids. Entoleter, Inc., who recently purchased the entire line from Hobam, Inc., is seeking new applications in the chemical, plastics, pharmaceutical, and food industries.

▶ **Fast Action Does It**—The irregular movement is the key to the sifter's success. Screen action holds the feed material in suspension, and provides many angles of approach to the screen holes for the particles. The screen, passing through this suspension 300 to 600 times/min., lets small particles through and keeps the coarse particles in motion.

Unlike many screens which handle fine materials, Cirlyptic screens do not need a screen vibrating agent. Their active motion means that they can operate without a back-up screen which holds rubber balls where they can bounce between the screens to add vibration to the screening surface. The advantages of this are threefold: construction is simpler, screen life is longer, and a source of contamination (abrasion of balls and screen) is removed.

▶ **Horizontal Layout** — Up to four product sizes can be obtained without screen stacking. Successively larger-mesh screens on the same level receive the oversize from each previous screen and remove the next size fraction. Adjustable barriers or fences between the screens control the residence time in each section from 3 sec. to several minutes.

Cirlyptic units, built of stainless steel or aluminum, have capacities up to 1,000 lb./min., depending on screens and feed size. The dust-tight cover lifts easily to give access to the screen, which can be replaced or removed for cleaning in less than a minute. Despite the action of the screen deck, practically no vibration is transferred to the floor, according to the manufacturer. — **Entoleter, Inc., New Haven, Conn.** 102A

Strong Alloy Steel

Lightweight alloy is three times stronger.

Outstanding strength and minimum weight are characteristics of new T-1 industrial alloy steel, according to the manufacturer. After heat treating, new steel has about three times the yield strength of structural carbon steel rolled to same thickness and weight.

T-1 steel can be fabricated and welded without loss of strength. Field welding is possible since no preheating or tempering is needed to obtain full-strength welds. First ap-

Joy Design Means:

HIGH EFFICIENCY IN THE COMPRESSION OF HOT GASES

Joy Axial Compressor delivers 104,000 SCFM, with inlet temperature of 1100° F., and inlet pressure of 200 psia.

The special problems posed by high inlet temperatures and pressures are routine to the designers of Joy's advanced axial and centrifugal compressors. Joy dynamic compressors provide economical solutions while achieving high efficiencies. Advanced aerodynamic principles are applied to obtain higher stage performance, whatever the inlet temperature and pressure conditions may be.

Joy dynamic compressors are available in sizes from 15 to 15000 hp for handling air or gases. Expansion turbines and complete process systems can be designed to your specifications. In addition, Joy can furnish positive-displacement type compressors with ratings from 15 to 1250 hp. Whatever your air or gas compression problem may be, Joy can supply the answer.

For complete information on Joy Dynamic Compressors, write for Bulletin 922-11.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY

JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

plication is for the Army Sergeant missile launching station and trailer transport. Use of T-1 steel wherever possible makes the units light enough to be transported by air to emergency sites.—**U. S. Steel Corp., Pittsburgh, Pa. 102B**

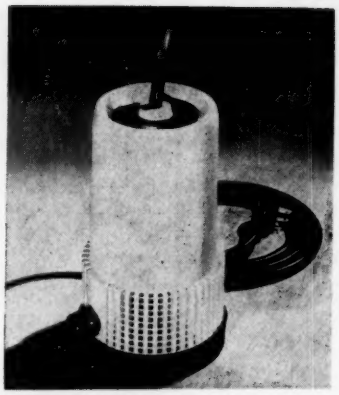
Strapping Material

Lightweight rayon strap fits package contours.

Made of high tenacity rayon cord, Avistrap cord strapping vies with steel strapping for packaging applications. Obvious advantage is lighter weight of shipping containers using new strap. Equivalent weight of same length of steel strapping: about five times heavier.

Thin, flat strap is made of many cords running longitudinally which give tensile strength comparable to steel, according to the manufacturer. Priced as much as $1/1,000 yd. less than steel of the same width, it comes in varying widths and can be imprinted.

Avistrap will not rust and can be disposed of by burning. A special tool applies the strap by crimping a metal clip on joints. Strap can be removed after service with scissors or other cutting tools.—**American Viscose Corp., Phila., Pa. 104A**

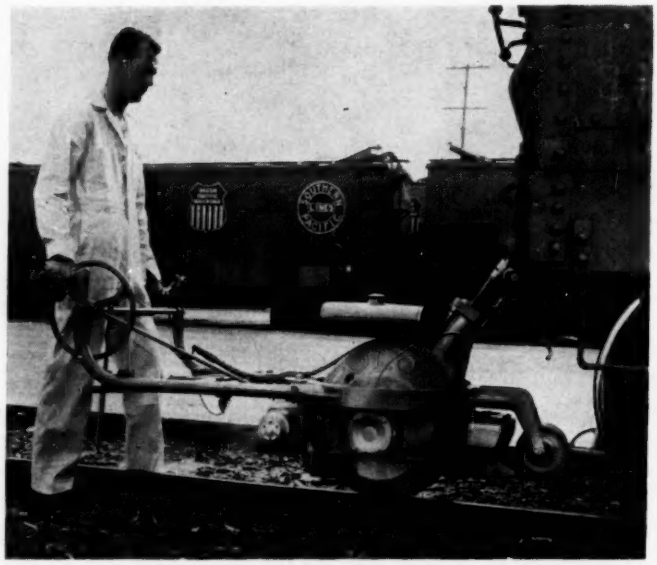


Sealless Sump Pump

Waterproof motor is submersible, noncorroding.

Made entirely of noncorrosive materials, a new lightweight, submersible sump pump features sealless, floodproof canned construction with pump and motor combined in a single unit. Nonclogging pressure switch provides automatic off-on operation without the use of floats.

Installed simply by connecting the discharge and plugging in the waterproof power cord, the 8-lb. unit delivers 700 gph. at 4-ft. head, 200 gph. at 10-ft. head.—**Fostoria Corp., Fostoria, Ohio. 104C**



Switch Engine (Junior Size) Moves 100-Ton Cars

The man above, together with an ILO car shunter, can replace a small switch engine. Powered by a one-cylinder, two-cycle, 6-hp. gasoline engine, the shunter moves cars, weighing up to 100 tons, at normal walking speed.

Flanged rubber drive wheel with gripper teeth holds to rail without steering or pulls the shunter over rails, ties or rough terrain to reach its point of use. By swiveling the carriage 90°, operator can insert shunter between adjacent cars or can walk beside moving car to observe the track ahead. A snow plow attachment is optional equipment. —Car Shunter Co. of America, Inc., Detroit, Mich. 104B

Portable A.C. Power

Remote use possible for standard electric tools.

Maintenance and construction crews are now offered a new device which enables them to use power tools where power outlets are not readily available.

Combining a storage battery with a diode-transistor current inverter, the Activerter device delivers 110-v. a.c. power to electrical tools. Recharging is merely a matter of flipping a switch on the unit and plugging it into a power outlet.

Rated for 500 w., the Activerter industrial model relies on adequate fuse protection to assure 7-8 yr. working life. For stationary application with existing batteries, the 24-lb. elec-

New all-stainless manifold uses stock Tri-Clover fittings and standard tubing. Four microporous "candle" filters shown provide final filtration for Cēpacol before filling operation at Merrell's Cincinnati, Ohio plant.

TRI-CLOVER installation helps assure product purity and boost Cēpacol® production for The Wm. S. Merrell Co.

How manifold redesign made an already efficient process even more functional . . .

A continuous flow process for manufacturing Cēpacol has assured The Wm. S. Merrell Company increased protection for the product purity of their antibacterial mouthwash gargle and turned in processing savings as well.

The new process resulted in an uninterrupted flow of material to packaging lines, and released manpower for other important production operations. It incorporates a unique "candle" filter manifold to promote thorough blending and to secure the highest possible purity of the product just prior to packaging. The original manifold had to be specially fabricated and was costly to operate.

Then, Merrell Company engineers and Tri-Clover Division specialists redesigned it, as shown above, to include all *stock;* Tri-Clover Stainless Steel Fittings, Valves and Tubing. The result: An already efficient process made *more* functional. The new stainless steel manifold is easier to clean, pleasing in appearance. It also cost them less to fabricate and less to operate than the original manifold.

This is another good example of how Tri-Clover's exclusive design features, in the hands of experienced Tri-Clover engineers, can help you to translate process efficiency . . . into process *savings.*

I-180

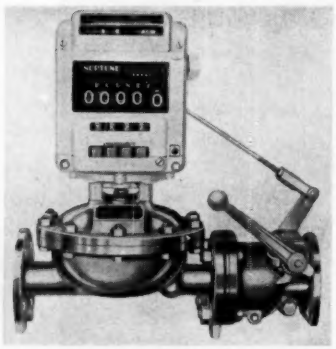
See your nearest Tri-Clover Distributor.

TRI-CLOVER

LADISH CO.
Tri-Clover Division
Kenosha Wisconsin

IN CANADA: Brantford, Ontario
EXPORT DEPARTMENT: 8 South Michigan Avenue, Chicago 3, Illinois
Cable TRICLO, CHICAGO

tronic part of the Activerter is available as a separate unit.—**Electric Storage Battery Co., Automotive Div., Cleveland, Ohio.** 104D



Automatic Meter

Measures preset quantity, then cuts liquid flow.

Stainless-steel meter designed for corrosive fluid service can automatically shut off flow in a line after a predetermined quantity of material is metered. Operator presses button on register face to set the quantity, then opens valve—the meter does the rest.

Capacity of the meter is 20 to 100 gpm. in the 1½-in. model. Units are available with extra equipment which will print tickets for records of material transferred. Automatic stop device on the meter can also actuate a switch which can be used to start and stop pumps, close valves or transmit signals.

Meters can be calibrated in gallons or pounds. Only one moving element is exposed to the liquid, which flows through the unit without pulsing.—**Neptune Meter Co., Long Island City, N. Y.** 106A

For More Information

about any item in this department, circle its code number on the

Reader Service

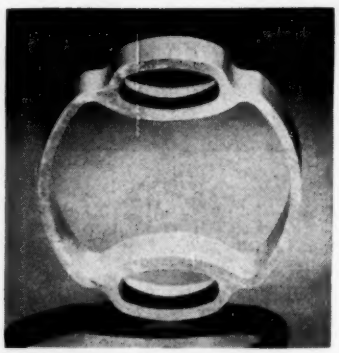
postcard (p 273)

Small Thermocouple

Small units offer low thermal inertia, light weight.

Coaxial thermocouples are now available with total outside diameter as small as 0.0062 in. Standard units are 0.014 in. in diameter. Copper tube is drawn over constantan wire coated with heat resistant insulating material which will not melt or break down dielectrically up to 3,000 F.

Couples are 8 in. long, lightweight, and offer low thermal inertia thanks to low mass of the welded junction. Other types of couples available include chromel-alumel, iron-constantan, and platinum-platinum rhodium. The entire couple can be insulated and enclosed in stainless steel if necessary.—**Uniform Tubes, Inc., Collegeville, Pa.** 106B

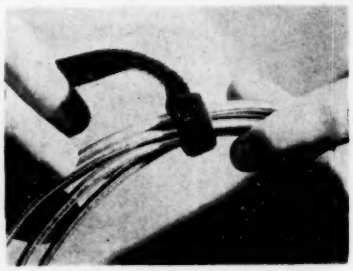


Aluminum Pipe

Integral tracing for heated product system.

Recirculation of heating fluids is simplified in a new aluminum pipe which contains two integral channels flanking a large product-carrying pipe. Heating medium, traveling through one small oval passageway to maintain temperature of bulk material flowing in the product line, can be removed at the terminal, reheated if necessary, and returned through the second channel.

Designated Duotrace, pipe is designed to eliminate extra piping used to return heating media for recirculation. It may also be used for circulation of refrigerants or for conveying several products in one piping system. — **Aluminum Co. of America, Pittsburgh, Pa.** 106C



Nylon Tape Fastener

Seals on itself, can be used over and over.

Originally developed for harnessing wires in groups, a new nylon tape that seals to itself can be used for temporary fastenings. Strip has tiny hooks on one side, soft loops on the other. It locks to itself when the two sides are pressed together.

According to the manufacturer, tape can be opened and closed 100,000 times without loss of holding power. It is a nonconductor and is resistant to static electricity. Typical process application would be for holding insulation on pipes or equipment where frequent access is required. — **Velcro Corp., New York, N. Y.** 106D

Porous Metal Filter

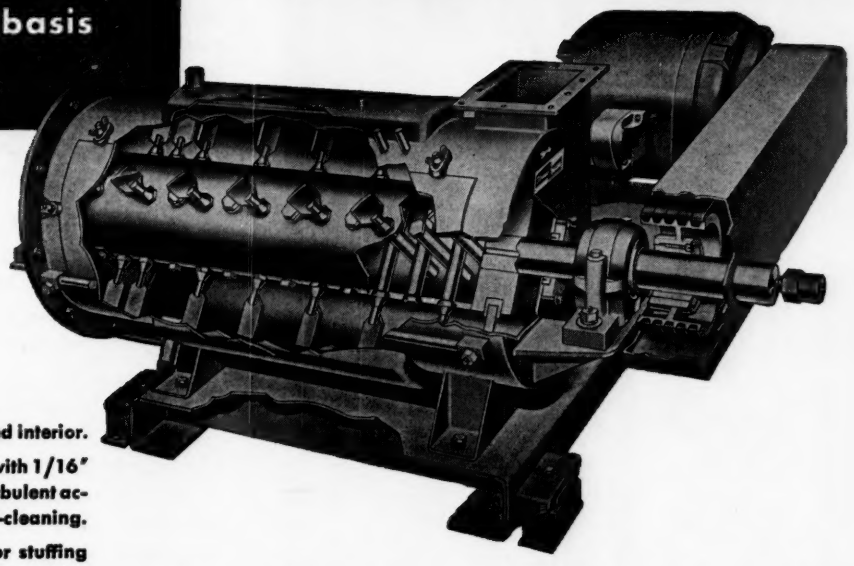
End caps sealed permanently by dovetail process.

Porous metal filters made by a special process have no defects or contaminants resulting from welded or cemented construction. High-pressure process uses special dovetailed construction, locks all components of the filter element together so securely that the filter

EQUIPMENT NEWS
Continues on . . . **Page 258**

There's one sure way to get intimate mixing of dry and semi-dry material on a continuous basis

Strong Scott TURBULIZER®



EXCLUSIVE TURBULIZER FEATURES

- Heavy steel shell with machined interior.
- Paddles revolve at high speed with 1/16" clearance to shell, creating a turbulent action that makes Turbulizer self-cleaning.
- Choice of lip type, air purge or stuffing box seals. All are of split construction for quick disassembly. (Lip type seal shown.)
- Hinged door is machined as an integral part of the shell giving a perfectly smooth interior surface.
- May be equipped with jacket up to 150 PSI for heat transfer medium.
- Hollow rotor shaft for heat transfer medium gives added temperature control.
- Inlet nozzles available for adding liquids.
- Quick acting heavy lug type catches—no nuts or bolts to remove.
- Tangential inlet and discharge prevent material hang-up.
- Heavy duty outboard bearings.
- Rotating joints for easy connection to heat transfer medium source.

The Turbulizer solves many dispersion problems in the chemical and food industries. Adjustable-pitch paddles, revolving at high speed, result in the combined action of turbulence, shear and impact providing intense dispersion. These actions can be varied to obtain desired results on a specific material.

A completely smooth inner surface with 1/16" clearance paddles, assures thorough mixing, eliminates material hang-up, leaves no dead pockets of unmixed material and provides a self-cleaning operation.

In addition to the numerous features shown here, advantages of the Turbulizer include better product uniformity, increased production, plus lower labor, installation and up-keep costs.

Write for complete details...

Please send information on the Turbulizer

NAME_____

TITLE_____

COMPANY_____

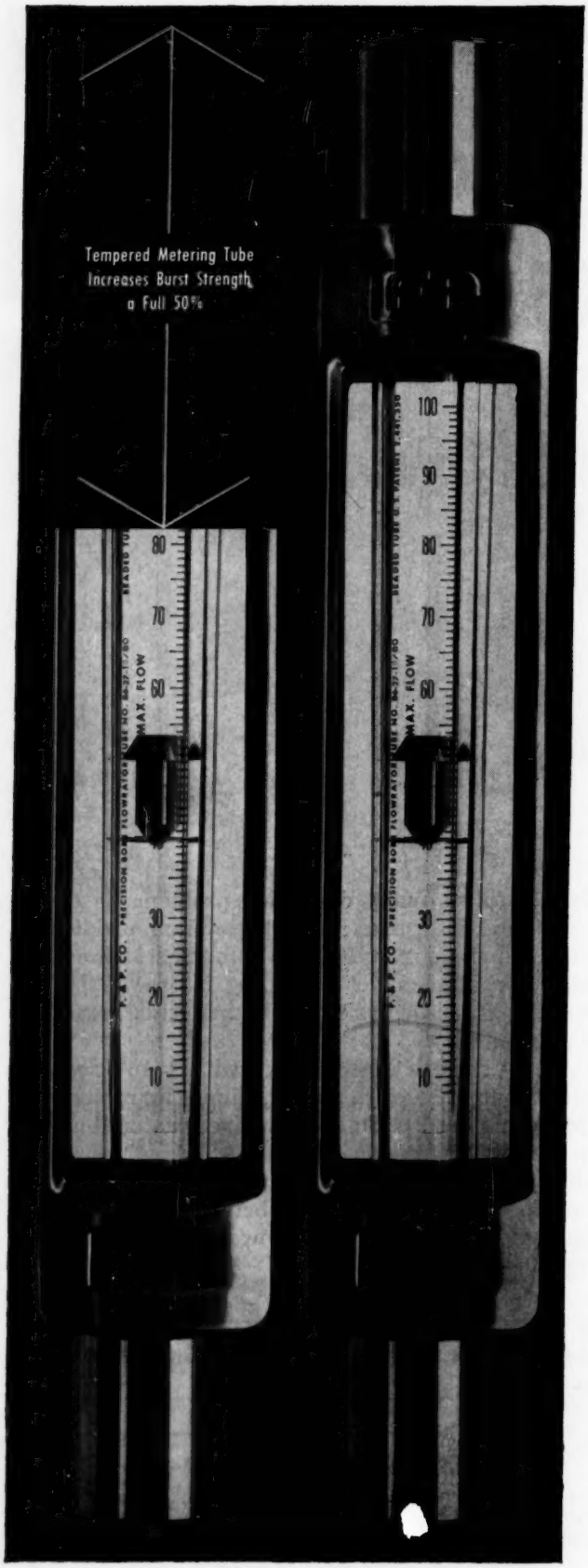
ADDRESS_____

CITY_____ STATE_____

The Strong Scott Mfg. Co.

451 TAFT STREET NE • MINNEAPOLIS 13, MINNESOTA

EQUIPMENT DESIGNED FOR BETTER PROCESSING



New Rotameters Take 50% Higher Operating Pressures

Now, you can use glass tube rotameters where you've never dared use them before. New tempered glass metering tubes take up to 50% higher operating pressures. Install them with complete assurance on process lines that formerly required metal tube meters. And gain a desirable extra margin of safety *wherever* rotameters are used.

How F&P did it

This major advance in flowmetering art developed from two well known facts:

1. Glass has ten to twenty times more compressive strength than tensile strength.
2. Endwise pressure and uneven peripheral compression (as from a stuffing box) impart a substantial tensile component.

First F&P eliminated that tensile component by developing the unique O-ring "floating tube" seal introduced in the 2700 Series flowmeter.

Now, F&P has developed a special method of tempering the precision borosilicate metering tube that boosts compressive strength *without causing distortion!*

Be sure you get a tempered metering tube

Tempered borosilicate metering tubes are now being supplied as standard equipment with all Series 2700 flowmeters at no additional cost. But you *must* specify this make and series to enjoy the increased pressure rating.

Get complete information...Now

Write for your copy of Bulletin 91-123, "The Rotameter Sheds Its Limitations".

Fischer & Porter Company, 160 County Line Road, Warminster, Pennsylvania.

FP FISCHER & PORTER COMPANY

Complete Process Instrumentation

These MANUFACTURING AFFILIATES carry Fischer & Porter engineering designs to the far corners of the earth: FISCHER & PORTER (CANADA) LTD., DOWNSVIEW, ONTARIO • FISCHER & PORTER LTD., WORKINGTON, CUMBERLAND, ENGLAND • FISCHER & PORTER G.m.b.H., GROSSELLERSHAUSEN, BEI GOTTINGEN, GERMANY • FISCHER & PORTER N.V., KOMEETWEG 11, THE HAGUE, NETHERLANDS • FISCHER & PORTER Pty. LTD., 184 HANNA ST., SOUTH MELBOURNE, VICTORIA, AUSTRALIA.

GREATER SELECTION

...another plus value
from **TUBE TURNS**

LIGHT WEIGHT FITTINGS FOR LOWER-COST PIPING!

You can use larger diameters of thin wall steel piping to get greater flow area, lighter weight, lower costs. Tube Turns offers the most complete line of forged light weight welding fittings for these economies. Here is just one of the many PLUS VALUES you get when you specify TUBE-TURN® products.

MORE!

MORE OF 'EM...QUICKER!

Another PLUS VALUE provided by your TUBE TURNS' DISTRIBUTOR

Tube Turns' 12,000 stocked items comprise the world's broadest line of welding fittings and flanges. You can buy any of these on *one order,* from *one source*... your nearby Tube Turns' Distributor. This *wide selection and prompt delivery* simplify purchasing, assure matching of specs, reduce job delays, cut costs. Outstanding *availability service* is just one of the many PLUS VALUES you get when you specify and buy top-quality TUBE-TURN* products. Others are shown here.

The trademarks "TUBE-TURN" and "tt" are applicable only to the quality products of Tube Turns.

DISTRICT OFFICES: Atlanta • Chicago • Dallas • Denver • Detroit • Houston • Kansas City • Los Angeles • Midland • New Orleans • New York • Philadelphia • Pittsburgh • San Francisco • Seattle • Tulsa
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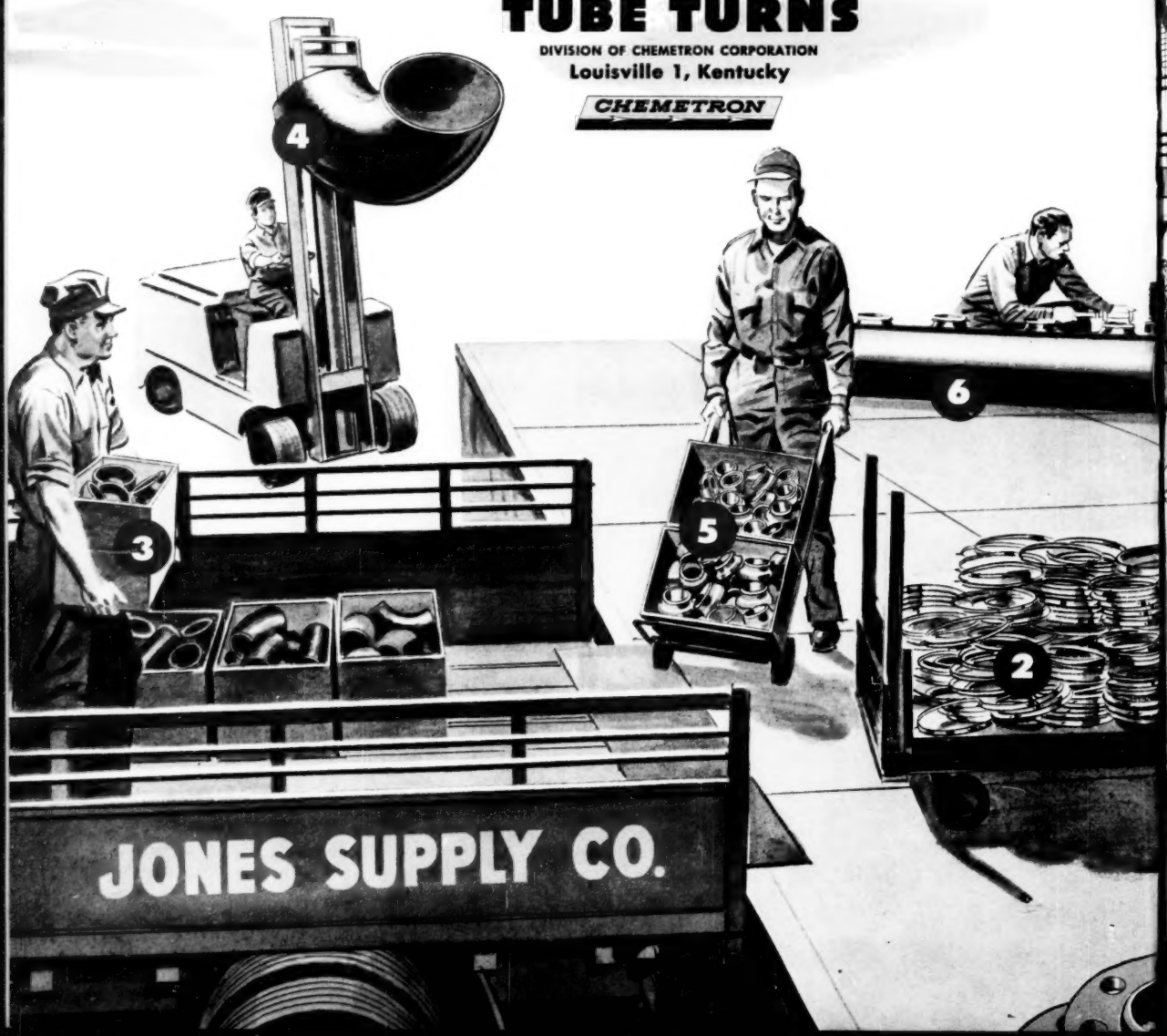
TUBE TURNS
DIVISION OF CHEMETRON CORPORATION
Louisville 1, Kentucky
CHEMETRON



MAIL COUPON FOR FREE DATA
on products featured here.

TUBE TURNS
224 E. Broadway • Louisville 1, Kentucky

Please send me the following bulletins checked:

- ☐ Taper Face Flanges
- ☐ Knock-off Spacer Rings
- ☐ Light Weight Fittings
- ☐ Scale-free Couplings
- ☐ Pipe Line Specials
- ☐ Wrought Iron Fittings
- ☐ Alloy Fittings

Company Name _____

Company Address _____

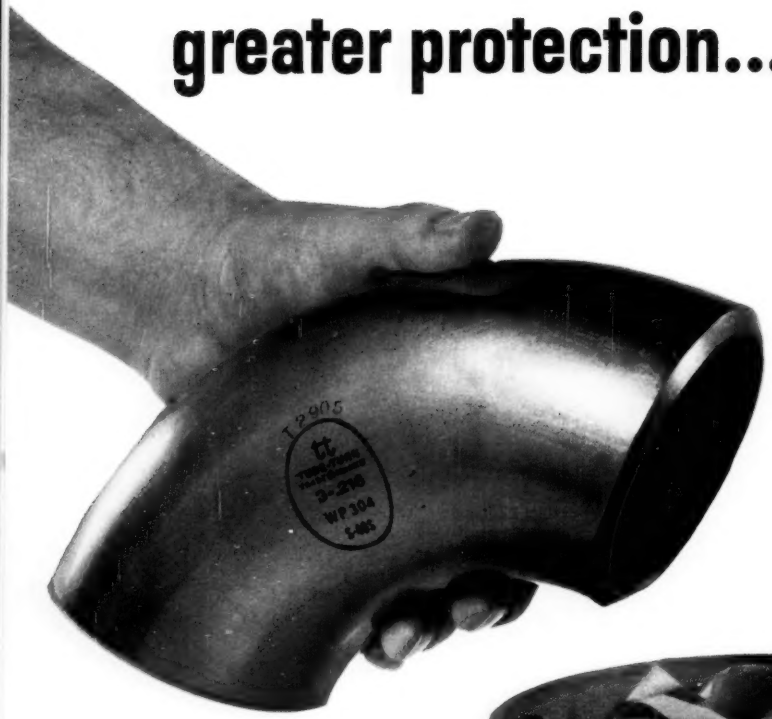
City _____ *Zone* ___ *State* _____

Your Name _____

Position _____

ANOTHER tt® PLUS

greater protection...convenience

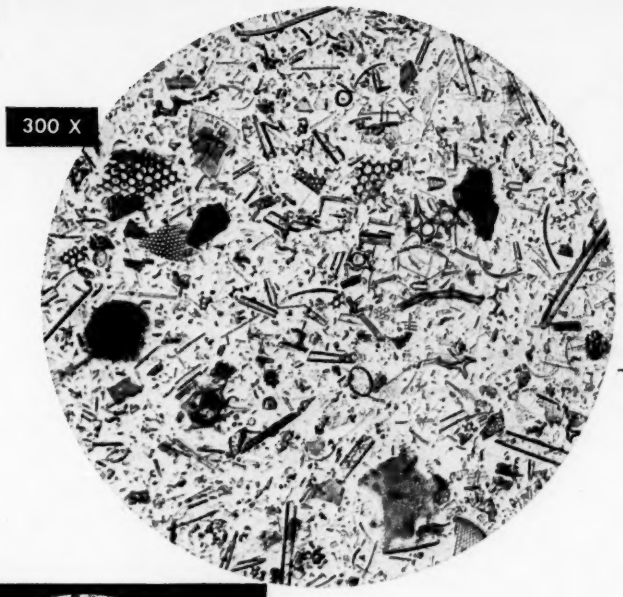


TUBE-TURN® ALLOY WELDING FITTINGS AND FLANGES ARE INDIVIDUALLY PACKAGED

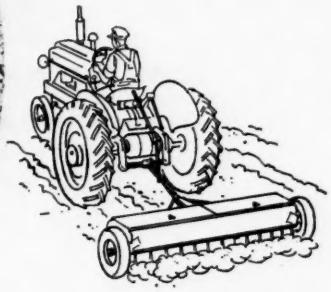
Here is an important new safeguard... and new convenience... for users of stainless steel, aluminum and other non-ferrous alloy piping. Tube Turns is now individually packaging all its fittings and flanges of these materials. Rugged containers protect each fitting from inspection to job site. And, fully marked, these containers simplify storage and identification.

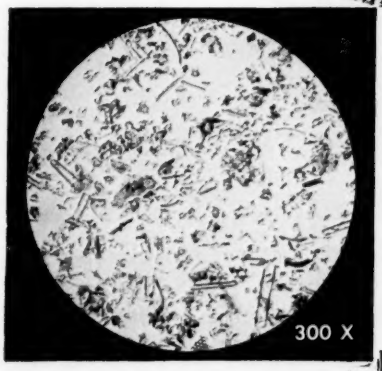
Here is another PLUS-VALUE you get when you specify TUBE-TURN® products and buy from your nearby Tube Turns' Distributor.

MORE!

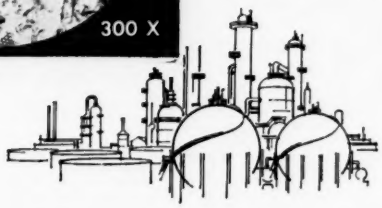


For fertilizer coating—Celite 379, a natural milled diatomite, provides the uniform conditioning needed to prevent caking of granular, mixed or prilled fertilizers—maintains good free-flow characteristics even after prolonged storage.

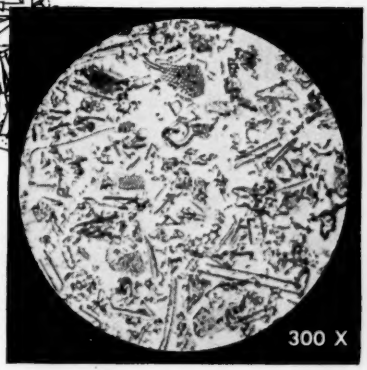




For catalyst carriers—Super Floss, finest particle size flux-calcined Celite grade, is used where a non-reactive porous silica support is needed. (Also available: special Celite supports in many preformed shapes for strength, high temperature stability, resistance to abrasion and attrition.)



As a paint-flatting agent—Celite 281, air-floated fines of flux-calcined diatomite, provides uniform and efficient flatting at low cost. Contributes to control of low angular sheen, durability, and faster drying.



In diatomites, Johns-Manville precision processing works for you

Celite diatomite absorbs its own weight of liquid . . . yet stays 'dry'

No matter which of the many available grades you choose, you can depend on a given volume of inert Celite* to retain its typical dry-powder characteristics even after absorbing its own weight of liquid.

Actually, Celite can absorb a total of more than twice its own weight. That's because a mass of the fine skeletal particles is approximately 93% air space or voids. Yet, in spite of this very high porosity, Celite is essentially non-hygroscopic.

Other unique properties—extremely high bulk, irregular particle shape and large available surface area—ideally suit Celite to hundreds of mineral filler applications. It is produced with precision from the world's purest commercially available diatomite deposit. It offers a wide choice of grades, each carefully controlled for complete uniformity.

For technical data on specific mineral filler or filtration problems, talk to your nearby Celite engineer. Or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

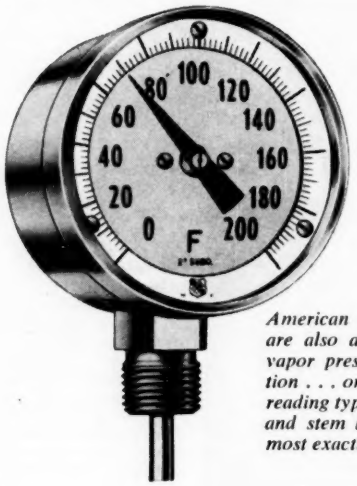
*Celite is Johns-Manville's registered trademark for its diatomaceous silica products

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

sharp

AMERICAN BI-METAL THERMOMETERS make accurate temperature readings sharp and sure at all check points



American Dial Thermometers are also available in mercury, vapor pressure, and gas actuation . . . on-the-spot and distant reading types . . . in sizes, ranges and stem lengths to meet your most exacting requirements.

sensitive

Any way you look at an American Bi-Metal Thermometer, you see exact working temperatures.

The two-level "Maxivision®" dial eliminates parallax effects. Numerals are on the lower level. Graduations are on the outer raised ring dial which presents a sheared edge to the tip of the pointer and in the same plane. To make readability even more accurate, the glass and graduated dial are closely spaced.

American Bi-Metal Thermometers are made of weather-proof stainless steel. All joints are welded to solid unity, then polished smooth so corrosion won't build up and destroy the thermometer's usefulness. And, you don't have to discard this thermometer even if the glass is ever broken. The bayonet lock bezel makes replacement easy.

Learn about the high sustained accuracy and long service life built into American Bi-Metal Thermometers. Phone your nearby industrial supply distributor for help in selecting the right type for each temperature check point in your plant. Or write for Catalog 100A.

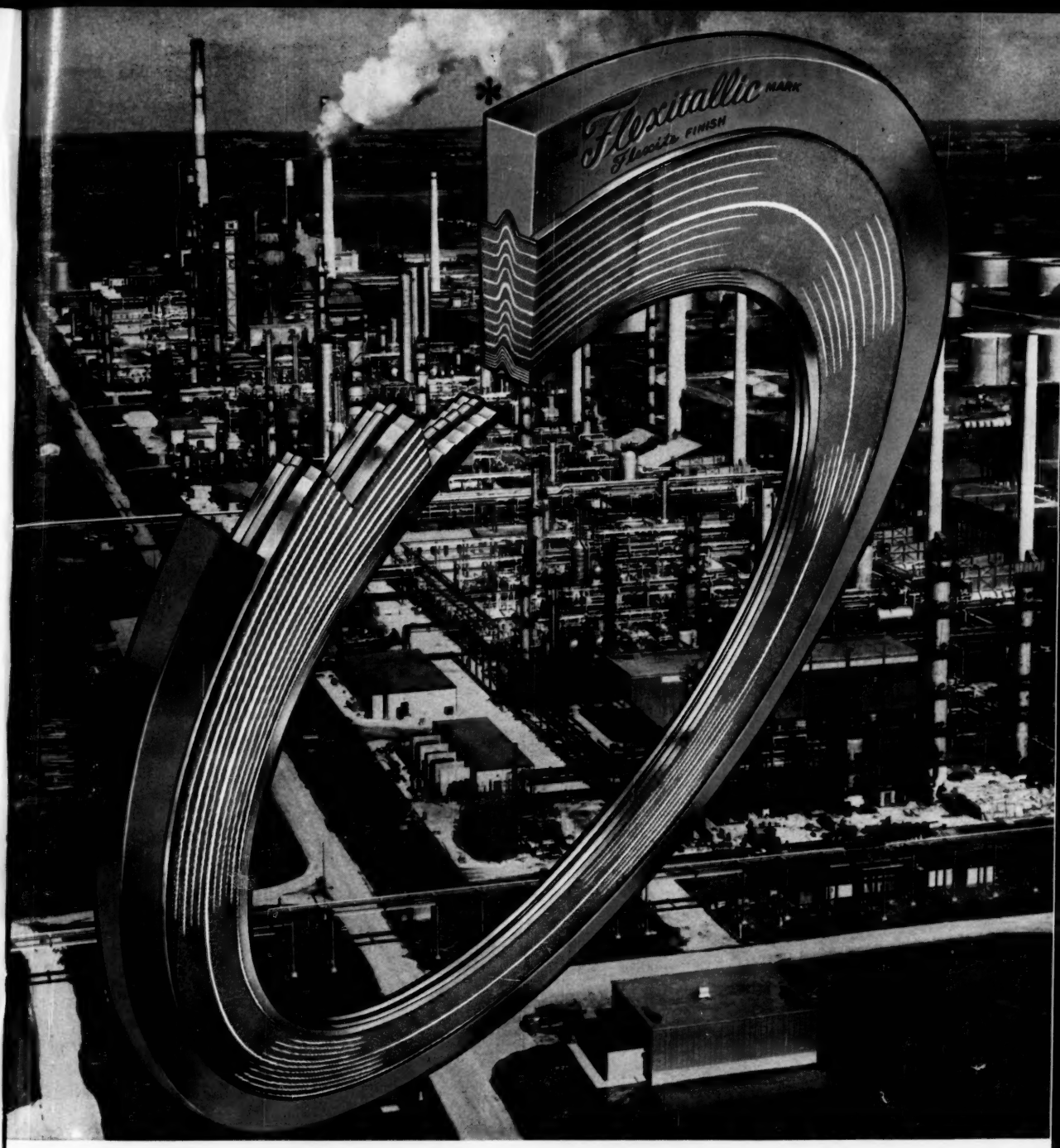
MANNING MAXWELL & MOORE INC. MM&M TRADE MARK

AMERICAN INDUSTRIAL THERMOMETERS

A product of

MANNING, MAXWELL & MOORE, INC.

Gauge and Instrument Division • Stratford, Connecticut
In Canada: Manning, Maxwell & Moore of Canada, Ltd., Galt, Ontario



End corrosion in gasket inventory

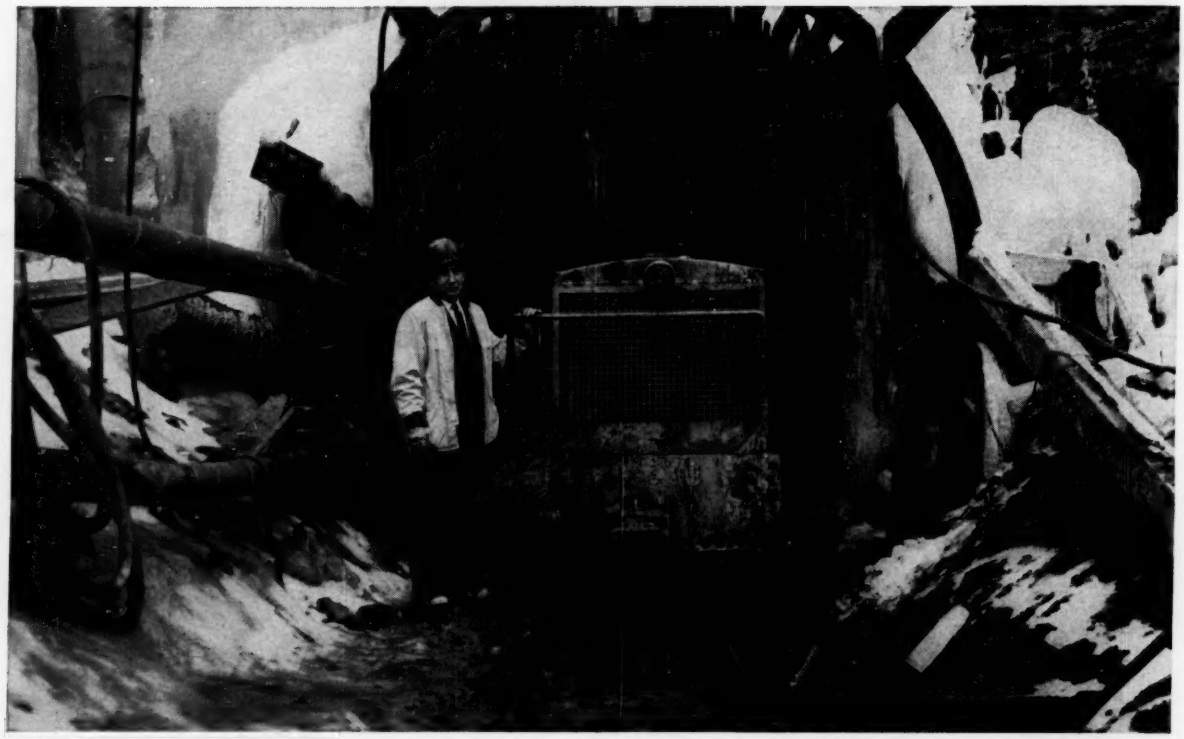
The gold Flexite Finish* for the metal gauge rings in Flexitallic Compression-Gauge Gaskets is new. It is highly corrosion resistant when exposed to severest weathering in open construction projects or in stock. The Flexite Finish provides for ease of identification and a clean, long-lived installation. Write for samples.

FLEXITALLIC GASKET CO., 8th & Bailey Sts., Camden 2, N. J.
Representatives in Principal Cities

TRADE Flexitallic® MARK
SPIRAL-WOUND GASKETS
WITH Flexite FINISH

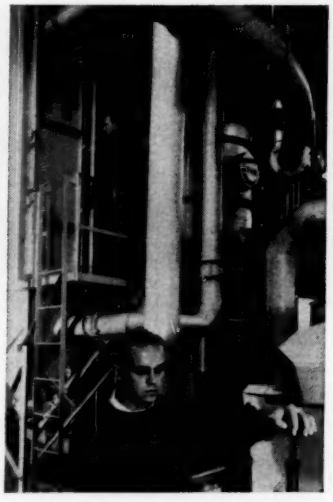
*The gold Flexite Finish is a development of the Flexitallic Gasket Co. (Originators of Spiral Wound Construction) — Register applied for on both name and color. Flexitallic Blue is our exclusive blue-dyed Canadian asbestos filler. Look for the blue and gold color combination as the mark of Flexitallic quality.

HOW *HERCULES* HELPS...



SET A TUNNEL DRIVING RECORD—For New York City's latest water tunnel, a 43.64 mile bore was completed in the record time of 841,000 man-days—ten months ahead of schedule. Clancy O'Dell, project manager, depended on Hercules® short-period electric blasting caps. Pioneering in the field of industrial explosives has always been part of Hercules' history and this extensive background is available through a world-wide staff of explosives technical service men.

IMPROVE CLEANING COMPOUNDS—New type liquid cleansing agents often depend upon Pamak® tall oil fatty acids for added effectiveness. Pamak is just one of the many Hercules products that is a part of today's formulations for modern cleaning compounds and liquid detergents.



PROTECT INDUSTRIAL EQUIPMENT—Protective coatings based on Parlon®, Chlorinated natural rubber, are being used from coast-to-coast. A typical example of the outstanding performance of Parlon coatings is at the Middlesex County Sewage Disposal Center in Sayreville, N. J., where a Parlon-based paint has been selected to protect equipment under extremely challenging conditions.

HERCULES

HERCULES POWDER COMPANY
INCORPORATED
900 Market Street, Wilmington 99, Delaware

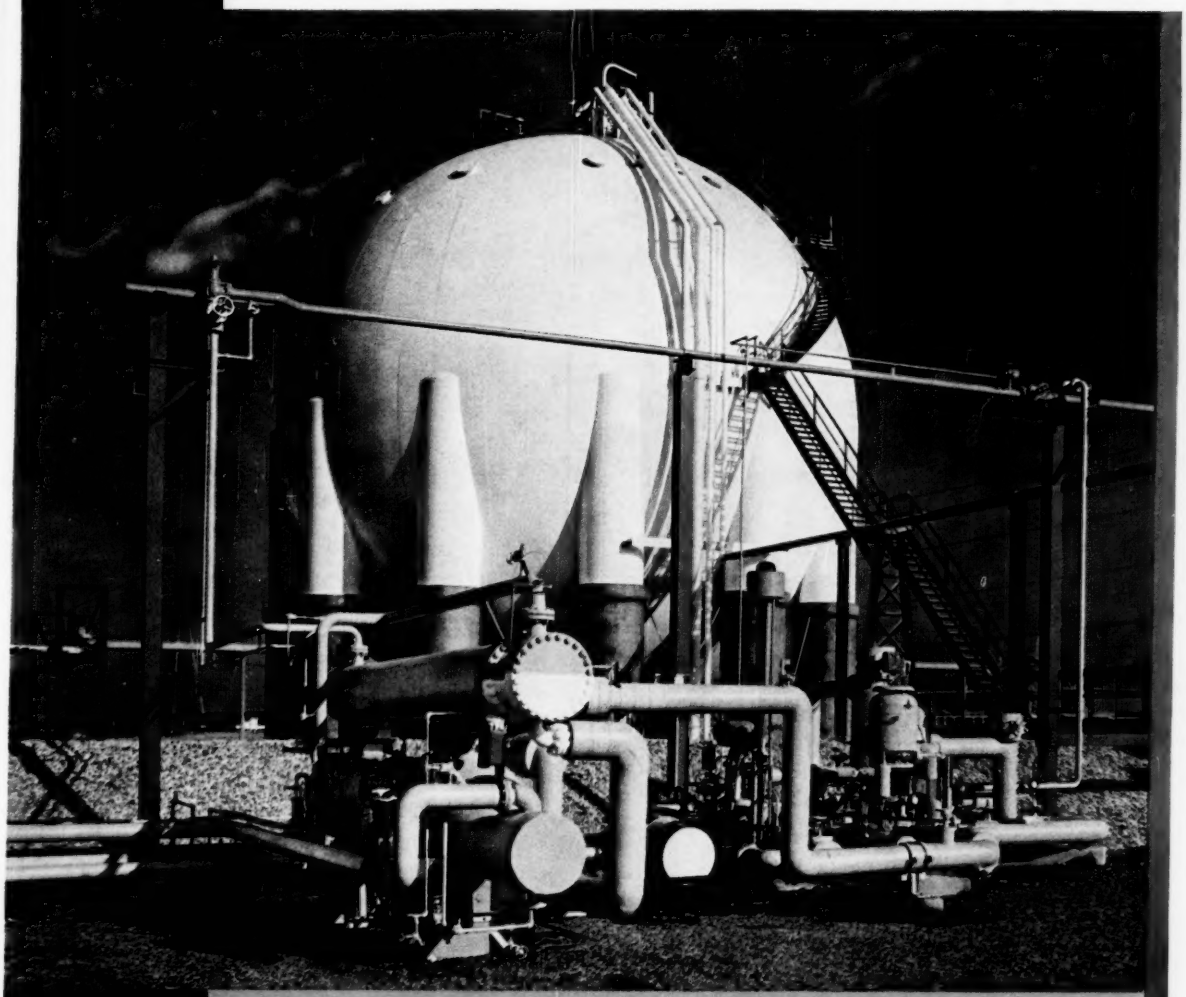
CHEMICAL MATERIALS FOR INDUSTRY

G60-5

Esso

AT ESSO'S BAYWAY ETHYLENE PLANT...

A STONE & WEBSTER LANDMARK IN LOW TEMPERATURE LIQUID STORAGE FACILITIES



Stone & Webster's skill and experience have added long-term profitability to industrial plants all over the world.

The largest above ground facilities in the United States for the low temperature storage of liquid ethylene have been placed in service by Esso Standard, Division of Humble Oil & Refining Company at Linden, New Jersey. With this installation, Stone & Webster Engineering Corporation continues its leadership in the low temperature processing and storage of hydrocarbons and chemicals.

Here Esso can economically store 20,000 bbl of liquid ethylene in one insulated sphere at –140 F. Stone & Webster engineered and constructed this installation... well within time and budget estimates.

This engineering skill and experience—extending into almost every industrial area — can be of service and profit to you on your next project. Please call or write our nearest office.

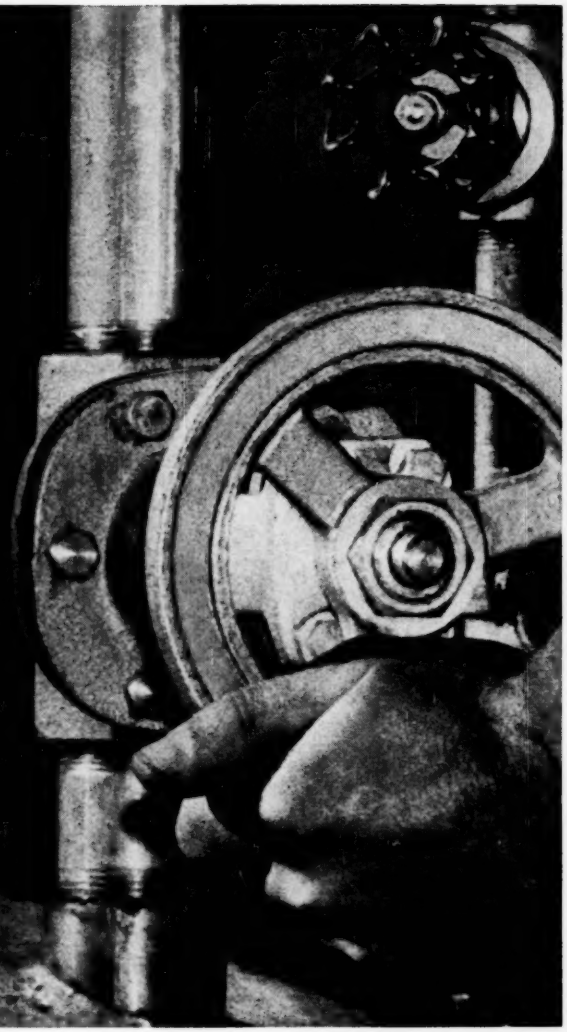
STONE & WEBSTER ENGINEERING CORPORATION

Affiliated with Stone & Webster Engineering Limited (London)

New York Boston Chicago Pittsburgh Houston San Francisco Los Angeles Seattle Toronto

Milestones in Hydride Chemistry

More processors turn to Potassium Borohydride for organic reductions!



And the reasons why are powerful! Price is one. Potassium borohydride is now the lowest priced commercially available borohydride reducing agent, $13.50 per pound*.

Selectivity of reductions is another big reason. Potassium borohydride goes to the heart of a specific reduction without side reactions, without affecting other reducible groups present and without attacking olefinic bonds. This selectivity makes it an ideal reagent for specific reductions of esters,† aldehydes, ketones, and acid chlorides.†

A white crystalline solid with a purity of 98% and density of 1.175 g/cc, potassium borohydride is stable and can be handled and stored safely in air without loss of purity. It can be used in conventional reaction equipment, too, using standard techniques.

As more and more processors have turned to potassium borohydride, a mountain of data concerning its usefulness has been collected. All of this helpful information is contained in the brochure, "$NaBH_4$—KBH_4 Manual of Properties and Reactions." MHI would be pleased to send you a copy without obligation.

*in 10,000 lbs. quantities.

†In a suitable salt-solvent system.

MHI'S TECHNICAL SERVICE TEAM . . . skilled service engineers and custom reaction pilot plant personnel can link any ideas you may have concerning hydrides to process realities for you. Call or write for details!

PIONEERS IN HYDRIDE CHEMISTRY

Metal Hydrides Incorporated

613 W. CONGRESS STREET, BEVERLY, MASSACHUSETTS

ECO ENGINEERING NEWS

the big name in small pumps for the process industries

Most Needs for SMALL CHEMICAL PUMPS POINT TO... ECO

ROTARY: If you want linear, non-segmented, non-foaming flows, ideal for shear-sensitive emulsions and safe for auto-detonating fluids—select the self-priming Eco ALL-CHEM Rotary displacement pump with twin opposed oscillating impellers. Designed for severe corrosive service. For reduced viscosities and temperatures to 250° F. Capacities to 10 gpm. Pressures to 100 psi. Suitable for metering in conjunction with Rotometers.

CENTRIFUGAL: If you want a widely applicable, corrosive-resistant centrifugal pump handling most chemicals, including slurries with particle size up to ¼ of an inch, as well as troublesome sticky fluids—select the Eco CENTRI-CHEM Pump. This pump was designed to meet the standardization programs of major, multi-plant chemical companies. Capacities to 40 gpm. Heads to 57 feet.

GEAR: If you require self-priming and intermittent or sustained operation with constant flow metering and reproducible accuracy within plus or minus 1 percent, depending on viscosity—handling all commercial chemicals, acids, oxidants, alkalies, aromatics, solvents—select the Eco GEARCHEM Pump. For temperatures up to 400° F and viscosities to 10,000 SSU. Capacities to 10 gpm. Pressures to 100 psi.

GREAT VERSATILITY

The widest variety of metals and non-metallics for every corrosion and contamination problem are utilized in Eco Pumps. These include the stainless steels, Stellite*, Hastelloy* B and C, monel, nickel, zirconium and titanium; Teflon†, phenolic plastics, Hypalon†, Nylon, Penton×, ceramic, carbon, etc.

Mass Produced and Stocked for Immediate Delivery

Eco Pumps are *not* "custom built" with attendant slow delivery and high cost.

They are stock pumps, produced in volume on automatic "program" machine tools where multiple operations are performed to reduce needless labor and handling. This results in lower prices, precision uniformity and complete interchangeability of parts to meet customer requirements and to facilitate field servicing.

Ask for literature on the complete Eco pump line.

*Union Carbide Trademarks. †duPont Trademarks. ×Hercules Powder Trademark.

ECO ENGINEERING COMPANY · 12 New York Avenue · NEWARK 1, N.J.

Do you check these points When Buying **STAINLESS STEEL** *Valves?*

- ☐ **How good are the castings?**
- ☐ **How precise is the machining?**
- ☐ **How rigid are the inspection and testing?**
- ☐ **How sound is the design?**

Just as important as a suitable stainless steel alloy are these four checks on valve quality. For long, dependable performance, a valve should rate *perfect* on every one.

There's a very good reason why you can be sure Jenkins Stainless Steel Valves will do that, unvaryingly:

For almost a century Jenkins has specialized in making valves. And making them to one standard of quality . . . the highest. Every operation and every worker is aimed at fulfilling that standard. The result is a product that can be backed by this 91-year-old assurance for valve users:

A Fair Offer

If you will put a Jenkins Valve, recommended for your particular service, on the worst place you can find . . . where you cannot keep other valves tight — and if it is not perfectly tight or it does not hold steam, oil, acids, water or other fluids longer than any other valve, you may return it and your money will be refunded.

Order these reliable Jenkins Valves from your local Jenkins Distributor. Ask him or write us for Stainless Steel Catalog No. 59SS. Jenkins Bros., 100 Park Avenue, New York 17.

JENKINS
LOOK FOR THE JENKINS DIAMOND
VALVES
JENKINS SINCE 1864 Jenkins Bros

Sold Through Leading Distributors Everywhere

MATERIAL CHARACTERISTICS	HARD TO VERY HARD	BRITTLE FRIABLE	SOFT	WET STICKY	FIBROUS
TYPE OF CRUSHER	Gyratory Hammermill One-way Reversible Impactor Jaw Single Roll	Bradmill Gyratory Hammermill One-way Reversible Impactor Jaw Single Roll	Bradmill Gyratory Hammermill One-way Reversible Impactor Jaw Single Roll	Hammermill Non-clog Single Roll Non-clog	Hammermill One-way Reversible Single Roll

HOW TO SELECT THE RIGHT CRUSHER FOR YOUR MATERIAL

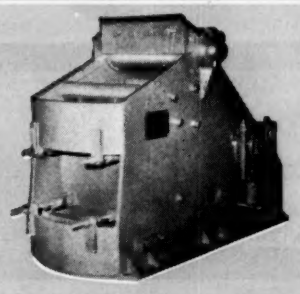
Crushing machines usually represent fair size investments. Also the cost of operation, and the quality and uniformity of the product, are two important factors in *your* product and profit picture.

So you want to be *sure* to select the right crushers.

The chart above will give you a clue. The types of Pennsylvania crushers mentioned can be considered for specific applications. But materials vary considerably in physical and chemical characteristics; and type of product desired and rate of production are equally important. So more help is usually needed.

EXPERIENCED ASSISTANCE

That's where Pennsylvania engineers and Pennsylvania laboratory facilities move in to help you. The engineers have a wealth of know-how. The laboratories offer unexcelled facilities for product analysis and test runs of your material. Together they will determine beyond any doubt the *right* crusher for *your* problem. This help is at your disposal freely and without obligation. See Pennsylvania first.



● Pennsylvania KUE-KEN Jaw Crusher—the crusher that employs the "crushing without rubbing" principle. Widely used for crushing a variety of materials in the chemical industries. Described in Bulletin 5012.

FREE BULLETINS

Just to increase your store of knowledge on crushing procedures, why not send for our bulletin on "How To Select a Crusher." It describes the various kinds of mechanical reduction, and the types of Pennsylvania crushers that supply each one.

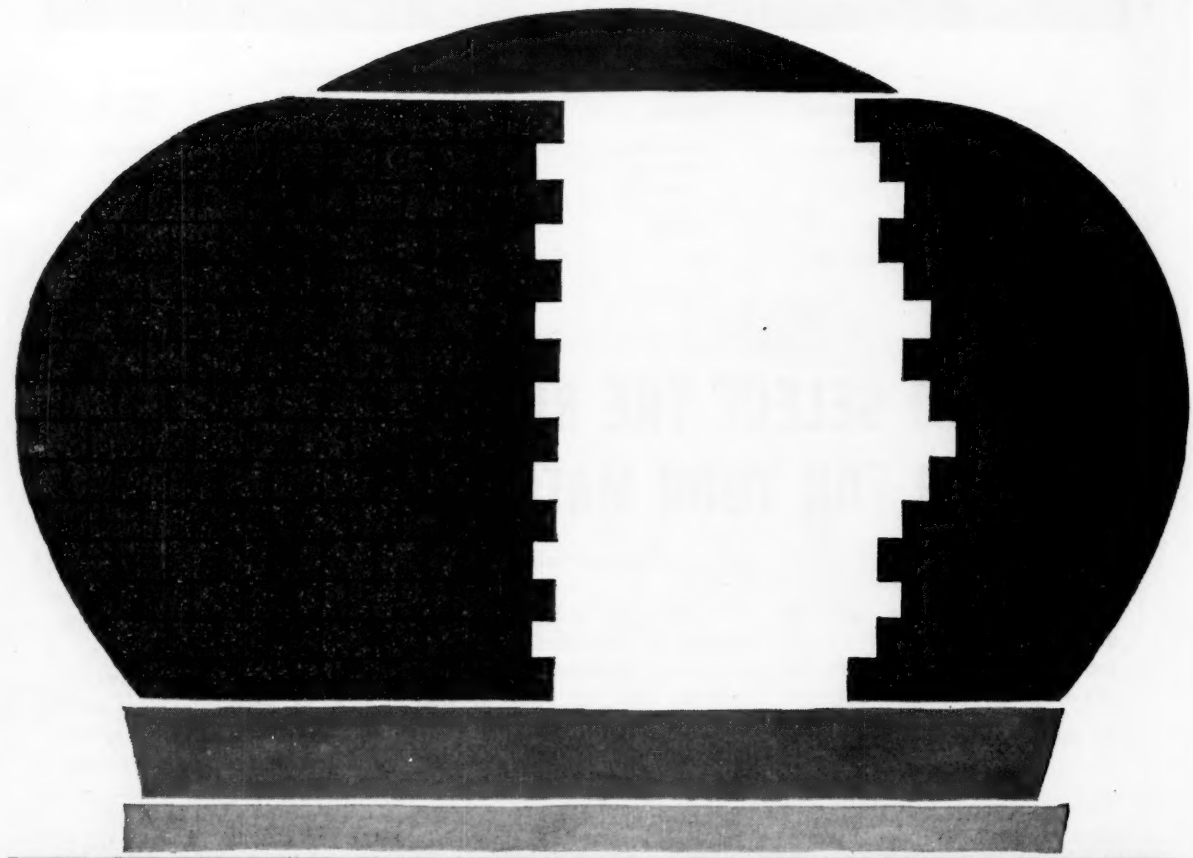
PENNSYLVANIA CRUSHER DIVISION
BATH IRON WORKS CORPORATION
WEST CHESTER, PENNA.

* * *

Over 50 years concentrated experience in all types of material reduction makes Pennsylvania your best source of crushers and engineering advice and service. Call on Pennsylvania with your next crushing problem. Representatives from coast-to-coast.

PENNSYLVANIA CRUSHERS

BATH-BUILT



FOAMGLAS® Insulation works for GULF

EVIDENCE: Back in 1951, Gulf Oil Corporation insulated four Hortonspheroids at the Port Arthur Refinery with FOAMGLAS—to help hold stored butane at 50°F. See how well FOAMGLAS worked.

Gulf reports that moisture-proof FOAMGLAS has maintained constant insulating value throughout the last nine years—to help prevent butane evaporation loss despite external temperature fluctuations. With the special application techniques used in applying FOAMGLAS, corrosion problems have been minimal and maintenance minor, since moisture can't get through the insulation to attack Gulf's spheroids' walls.

Get all the details and see for yourself. Write today for our Gulf Case Study report and your free copy of our Industrial Insulation Catalog. Pittsburgh Corning Corporation, Dept. H-60, One Gateway Center, Pittsburgh 22, Pennsylvania. In Canada: 3333 Cavendish Boulevard, Montreal, Quebec.

Pittsburgh Corning makes available a complete line of insulation accessories for use with FOAMGLAS.

PITTSBURGH PC CORNING

and they run
and they run
and they run

1903—
Indianapolis.
a trolley car.
a rolling adventure surrounded by noise.
pennies, nickels, children . . .

and inside—
a Fairbanks Morse electric motor.
it drove the trolley over thousands of miles
and rode with it
into glorious retirement.

pick a year—
from the turn of the century until now.
pick a month,
pick a day,
pick a city,
pick a town—
our motors are in its history . . .
pulsing, driving, working.
powering the things we need
and the things we want.
pushing our daily advances.
pulling us into the future.

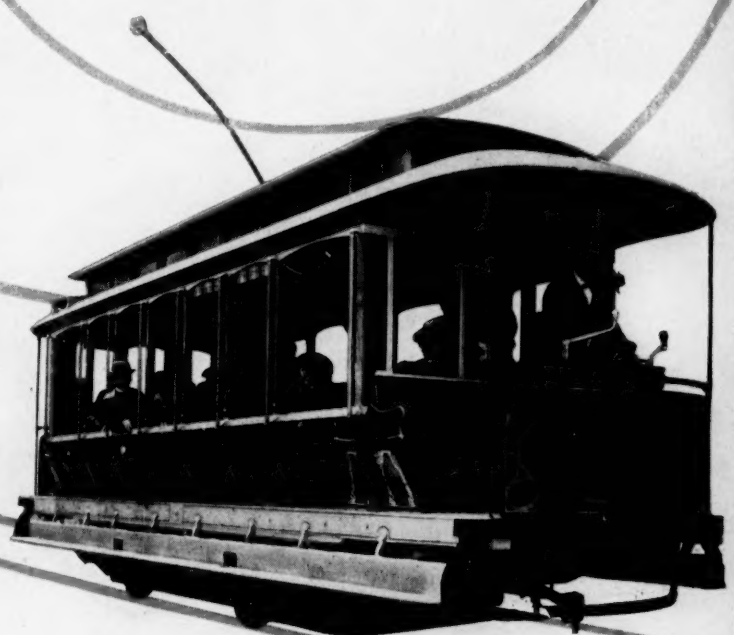
today our electric motors
are bigger and better.
they're also smaller and stronger,
surer and more powerful.

they operate in air and underground,
in freezing temperatures and underwater,
in gas-filled areas
and radiation atmosphere.

they power oil burners and compressors,
elevators and fans,
pumps, conveyors and saws.

they are adaptable
to every phase of every industry
for many reasons and more purposes.
they keep us growing
and they keep us improving.
they keep us ahead of the day before
and on the heels of the day ahead.

they are our heartbeats
and they run and they run and they run.

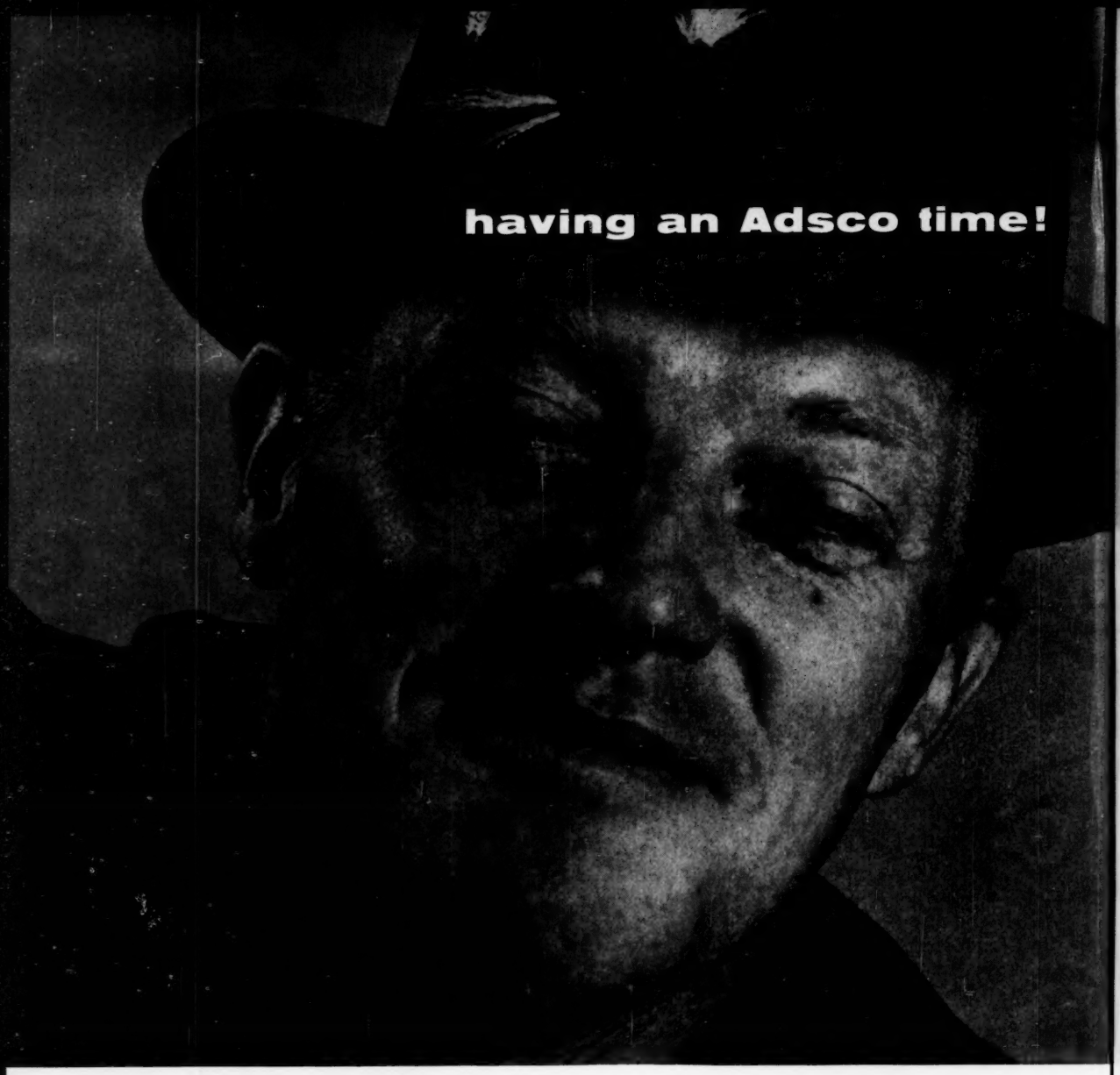


Fairbanks, Morse

A MAJOR INDUSTRIAL COMPONENT OF **FAIRBANKS WHITNEY CORPORATION**

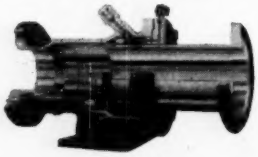
The electric motor is one of the most versatile sources of power ever developed. It is economical, practical and time-resistant. Fairbanks-Morse electric motors can turn out ½ horsepower or 10,000 horsepower, meet every known job demand within this range or be custom-specified to your blue-print projections. Whatever your production needs or plans may be, our electric motors can power them.

If you are in a field where power for production must be efficient, effective and dependable—we suggest that you consider our great variety of electric motors. For further information please write to: Mr. George H. Herrick, Vice President and General Manager, Electrical Division, Fairbanks, Morse & Co., Freeport, Illinois.

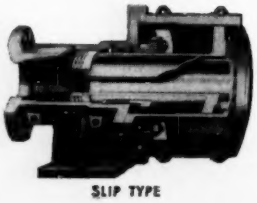


ONLY ADSCO HAS ALL 3 TYPES OF EXPANSION JOINTS

CORRUFLEX PACKLESS



RAM-PAK



SLIP TYPE

... real peace of mind, the result of doing business with completely reliable Adsco. For more than 80 years, Adsco has carefully handled customers' expansion problems in their piping systems, from engineering through manufacture. Consult Adsco for your peace of mind.

Write for comprehensive catalogs

ADSCO ENGINEERED PRODUCTS

Sold, Engineered and Manufactured by

YUBA HEAT TRANSFER DIVISION

HONESDALE, PA.

World's Oldest and Largest Manufacturer of Packed and Packless Expansion Joints

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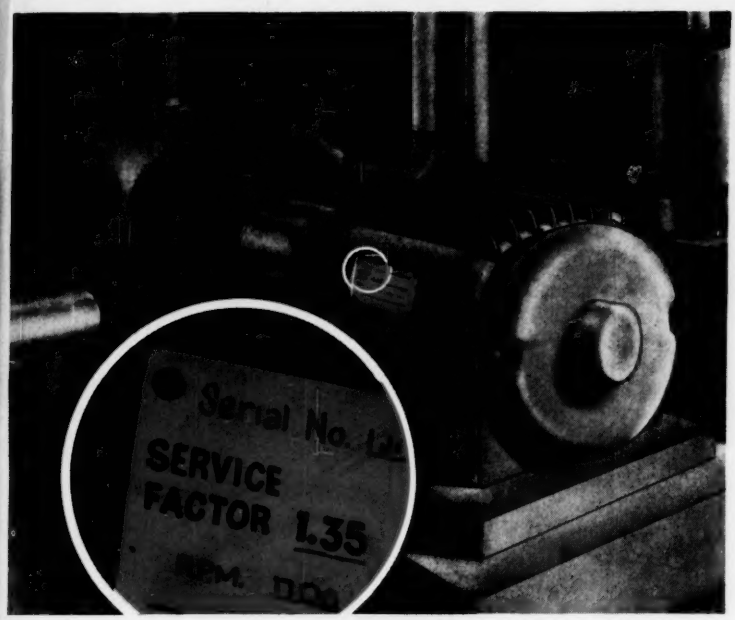
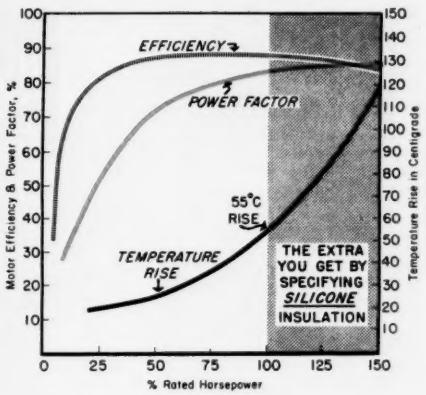
SILICONE NEWS from Dow Corning

New Service Factor Motors Cut Costs





Specify High Service Factor Motors for lowest initial cost, lowest operating costs . . . maximum reliability.

Leading manufacturers now offer motors designed to an entirely new concept. These motors are available in standard NEMA frames of the same size used for conventional motors of the same rating, but look alikes don't perform alike.

These new motors, insulated with Dow Corning Silicones, have a built-in reserve to carry overloads of twenty-five to fifty percent above nameplate horsepower rating. Here's what this means to you:

Simplified Motor Specifications: Specify motors that are silicone insulated for high service factor. With nameplate horsepower ratings identical to nominal loads, these motors will handle temporary, or even continuous overloading. No need to calculate maximum possible load and add a safety factor. It's already built in.

More Efficient Power Use: Power factor problems are reduced . . . excessive power bills resulting from part-load motor inefficiencies are brought in line. Because motors operate at rated output, the need for capacitors to correct power factor is substantially reduced.

Less Installed Horsepower: With motors rated to match normal loads, total installed plant horsepower will be substantially less. Using conventional methods of determining distribution system needs, transformer and switchgear requirements are lower—less costly units can be safely specified.

Motors insulated with Dow Corning Silicones for high service factors are available now from leading motor builders. For more information on what silicone insulated equipment can mean to you, write Dept. 1806.

How do manufacturers build so much extra into a motor? By substituting an insulation system made from Dow Corning Silicones for the Class A insulation system used in standard lines. Only the insulation changes. Frame, electrical steel and copper remains the same. And there's one change on the nameplate.

Service factor rating goes up. On a TEFC motor, for example, service factor goes up from 1.00 with Class A insulation materials to somewhere between 1.25 and 1.50 when silicones are used, depending on manufacture and horsepower rating.

Handling liquid of varying viscosity, this 5 hp, 1.25 service factor motor withstands overloads, including those created by excessive tightening of pump packing glands.

Motors insulated with Dow Corning Silicones give reliable operation in almost any surroundings—regardless of high ambients, moisture, many corrosive atmospheres. And on the basis of capability, high service factor motors generally cost less than conventional motors.

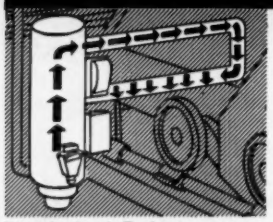
SPECIFY Dow Corning Silicones and SAVE!

first in silicones

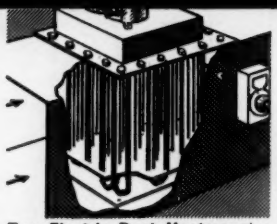
Dow Corning CORPORATION
MIDLAND, MICHIGAN

ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D. C.

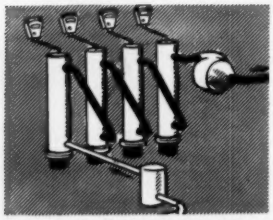
Call your CHROMALOX Man for heating answers



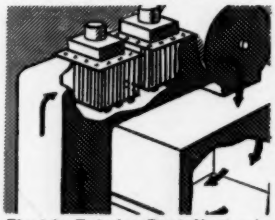
Electric Heat Exchanger superheats steam to 750°F for setting ink on printing press.



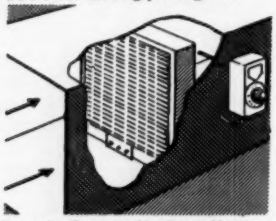
Two Electric Duct Heaters give fast heat-up and accurate temperatures in high velocity oven.



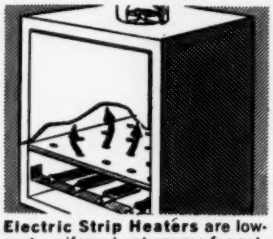
Electric Air Preheaters produce high volumes of air heated to 950°F for testing jet engines.



Electric Tubular Duct Heater is easily installed in air ducts for temperatures up to 1200°F.



Electric Forced Air Duct Heater easily fits ducts for comfort heating or process heat to 950°F.



Electric Strip Heaters are low-cost, uniform heat source for natural convection ovens to 750°F.

STEAM? AIR? OTHER GASES? ...Only CHROMALOX heats so many things, so many ways

There's one best way to do any job. And you get the best results only by using that one best method.

Regardless of what your heating problems may be . . . your best chance of finding the best answer is to call your Chromalox Man.

- He represents more than 15,000 different types, sizes and ratings of electric heaters and heating elements . . . the world's largest line.
- He orders from the world's largest stock.
- And he is a heating expert . . . he understands your problem and can help you find the answer.

No matter what your heating problem is . . . solids, liquids or gases . . . call your Chromalox Man for the efficient, electrical answer. Or, check the boxes below, write your name, title, and address at the bottom of this page and mail the coupon to us.

91847

Edwin L. Wiegand Company
7500 Thomas Boulevard, Pittsburgh 8, Pa. • Churchill 2-6400

☐ Send me Catalog 60 (General Industrial heating applications).

☐ Send me specific information on the heating problems I have outlined on the sheet attached.

☐ Have a Chromalox Representative contact me.

☐ Do not have a Chromalox Representative contact me.

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Granite 4-3933
WICHITA, KAN.
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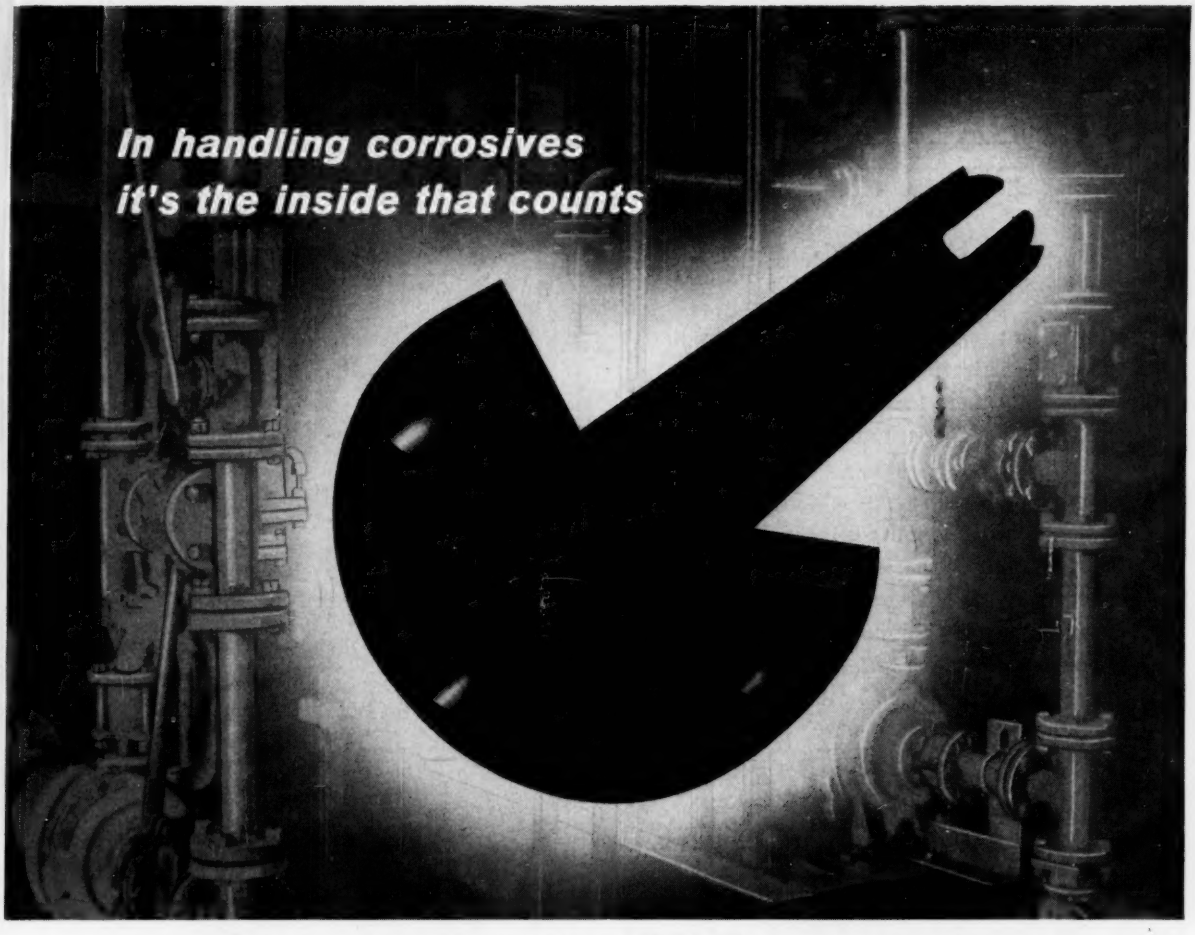
CHROMALOX ELECTRIC HEAT



Pipe lined with TEFLON® cuts maintenance and replacement costs

When a piping installation must operate under two or more of these conditions: acidic, solvent, high temperature, oxidation—pipe lined with a TEFLON TFE fluorocarbon resin is uniquely applicable. Unlike other materials commonly used in piping installations, TFE resins are not affected by acids, alkalis and solvents at high temperatures, and they withstand even the aqueous fluorides.

In many cases, pipe lined with TEFLON TFE resins has continued to give satisfactory service after years of use where other pipe required regular replacement after a month or two. Maintenance costs and costly process shutdowns have been sharply reduced. For example, sections of pipe lined with a TEFLON TFE resin in an operation for H_2SO_4 recovery from coal-tar sludge at 250°F., at 50 psi, have required no maintenance in over 4 years of service.

Pipe lined with TEFLON TFE resins offers many other advantages. TEFLON TFE resins are rated for use up to 500°F. Pipe liners made from TFE resins won't shatter under vibration or physical or thermal shock. The non-adhesive properties of TEFLON TFE resins make them ideal for handling sticky or viscous substances. The liner flared over the flanges provides complete protection for the metal from the process fluids and eliminates the need for additional gasketing. Installation costs are further reduced because the pipe is equipped with standard flanged fittings which are easily connected. And the need for careful aligning, hanging, welding and other special procedures is eliminated.

For long service life, greatly reduced maintenance and downtime, and greatly increased plant safety, install pipe lined with TEFLON. For more details on properties and performance send for the new bulletin on "Lined Pipe"... and for more general information, ask for the fact-filled booklet "Designing with TEFLON". Write to: E. I. du Pont de Nemours & Co. (Inc.), Polychemicals Department T-10-6, Room 2526, Nemours Building, Wilmington 98, Delaware.

In Canada: Du Pont of Canada Limited, P.O. Box 660, Montreal, Quebec.

DU PONT REG. U.S. PAT. OFF. **TEFLON®** FLUOROCARBON RESINS

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

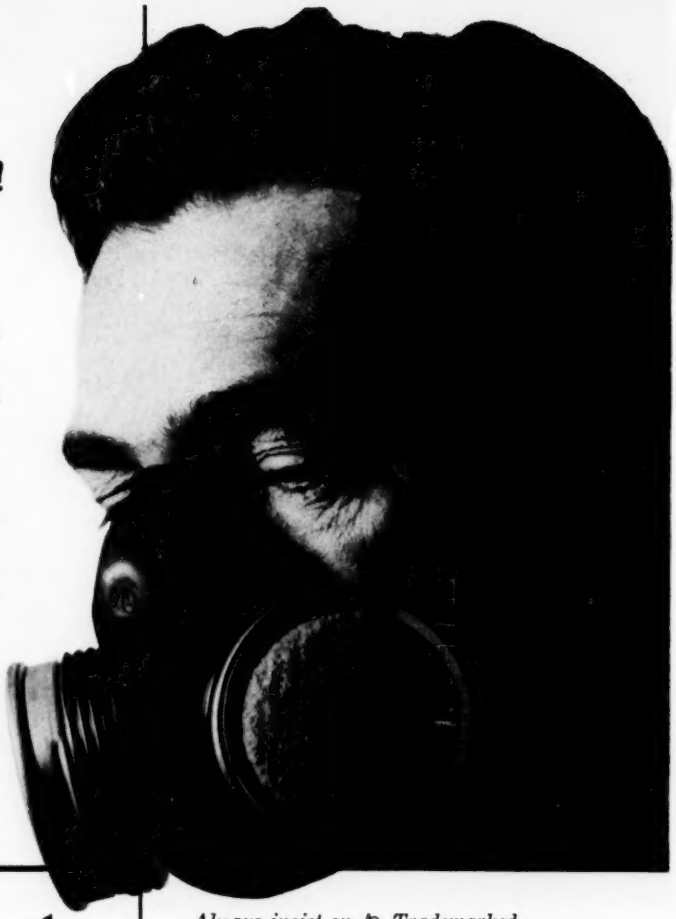
TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resin.

VERSATILE PROTECTION!

One of 16 Respirators in 1

Here's the respirator for workers exposed to low concentrations of All Dusts not significantly more toxic than Lead, Mists and Organic Vapors simultaneously. *Doubly Approved* — BUREAU OF MINES Approval No. 2305 and also approved by U. S. Dept. of Agriculture for use against Parathion insecticide. Respirator quickly converts to one of 15 other respirators by interchanging filter units. The economy of one face piece simplifies stock, saves money. "Balanced" R-55 cartridges provide very long service life.

AO R-5055 RESPIRATOR



American Optical COMPANY
SAFETY PRODUCTS DIVISION
Southbridge, Massachusetts

Always insist on Trademarked Safety Products. Your Nearest AO Safety Products Representative can supply you.

Safety Service Centers in Principal Cities

Even MORE Versatile Protection!

One of Thirty Two Respirator-Goggle Combinations

Protects *both* eyes and respiratory passages against All Dusts, Mists, Fumes and Organic Vapors. Facepiece permits wear of spectacles under the mask. Inhaled and exhaled air does not pass thru goggle part of unit. Heavy duty lens won't fog, will stand severe impact and is easily replaceable. Comfortable, quickly adjustable head harness. Combination converts to one of 31 other respirator-goggle combinations for protection against many other hazards including radioactive particulate matter. Available with ventilated goggle section (R-40561) as well as gas tight goggle section.

AO R-41561 COMBINATION

Your Surest Protection...AO SURE-GUARD Products

Just add water...

for reliable, low-cost high temperature protection

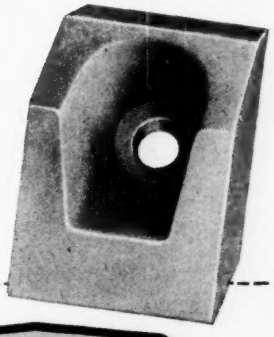
With Norton ALUNDUM* Castables it's practically that simple and economical to make refractory shapes that would otherwise cost you far more. You make your own molds and, following a few simple directions, mix and pour your own furnace arches, domes, covers, spouts for melting furnaces, etc. Even the most complex shapes can be formed easily and inexpensively. And ALUNDUM Castables are ideal for furnace conditions in all types of atmospheres at temperatures up to 3,300°F.

This versatile castable is available in two types: 1. ALUNDUM 33-I Castable, made up principally of pure fused aluminum oxide *bubbles*. Its light weight and high insulating properties suit it for use in furnace applications subject to high temperature radiation, but mild gas and flame erosion. It is often used as a back-up for ALUNDUM 33-HD material in linings and roof arches. 2. ALUNDUM 33-HD Castable, made up principally of dense, fused *grains* of pure aluminum oxide. It is ideally suited for forming dense, monolithic surfaces where conditions are more severe — provides positive protection against flame impingement and abrasion.

Cut down time for repairs, your inventory of required shapes . . . and save with Norton ALUNDUM Castables. Write for new catalog with complete characteristics and casting instructions. NORTON COMPANY, 505 New Bond Street, Worcester 6, Massachusetts.

*Trade-Mark Reg. U. S. Pat. Off. and foreign countries

Imagine the savings in making complex shapes like this tapping block right *in your plant.*



NORTON
REFRACTORIES
Engineered... Rx ...Prescribed

75 years of . . . **Making better products . . . to make your products better**

NORTON PRODUCTS: Abrasives • Grinding Wheels • Machine Tools • Refractories • Electro-Chemicals — **BEHR-MANNING DIVISION:** Coated Abrasives • Sharpening Stones • Pressure-Sensitive Tapes

ARMCO STEELS / for Chemical Processing

New steels are born at Armco

Look at the Unusual Properties of Armco 17-4 PH Stainless Steel!

Corrosion Resistance: Similar to Type 302 Stainless Steel
Ultimate Tensile Strength: 145,000-200,000 psi*
Yield Strength, 0.2% Offset: 125,000-185,000 psi*
Elongation in 2″: 14%-10%*
Hardness: Rockwell C33-44*

* Low temperature heat treatments (900-1150 F) will give properties within the ranges listed.

The unusual combination of properties offered by Armco 17-4 PH Stainless Steel enables you to solve difficult problems in selection of metals for chemical processing equipment.

With 17-4 PH you can:

Reduce galling.

Minimize wear and abrasion.

Gain excellent corrosion resistance with the strength and hardness of hardenable stainless steels.

Minimize erosion-corrosion.

Design for temperatures up to 900 F.

Cut costs because more expensive alloys can be replaced.

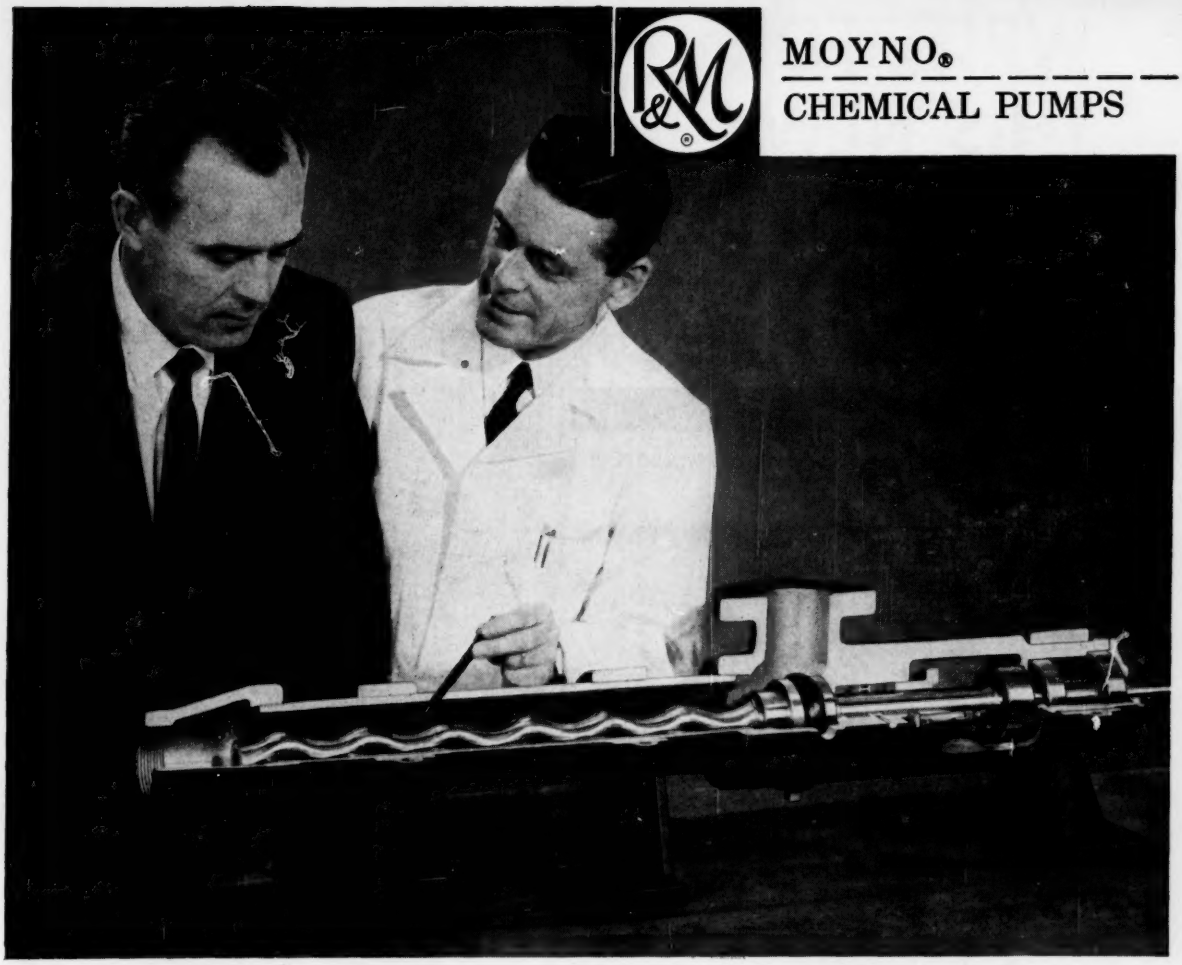
Obtain good resistance to stress-corrosion cracking.

Proved service in applications such as pump, mixer, and compressor shafts; valve, stems, trim and plugs; high strength studs and bolts; piston rings; wear plates; and similar parts has demonstrated the economy and multiple advantages of Armco's precipitation-hardening stainless steel. Specify it to give the equipment you make or use superior performance at less cost.

Write to Armco Steel Corporation, 1310 Curtis Street, Middletown, Ohio, for complete information. Ask for a free copy of Armco's new booklet, "How Armco Stainless Steels Serve the Petrochemical Industry."

ARMCO STEEL

Armco Division • Sheffield Division • The National Supply Company • Armco Drainage & Metal Products, Inc. • The Armco International Corporation • Union Wire Rope Corporation



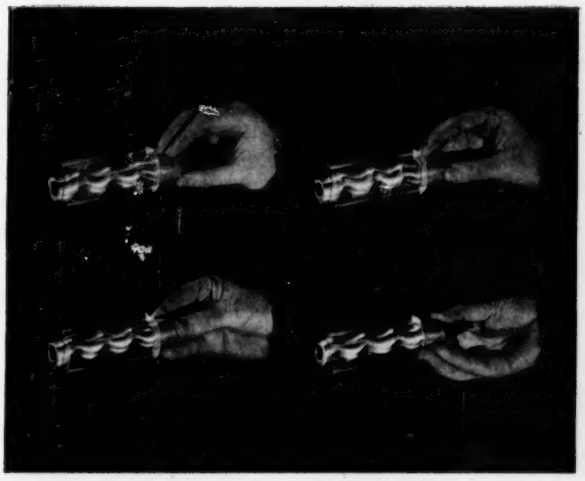
MOYNO®
CHEMICAL PUMPS

MOYNO® Progressing Cavity Pumps Handle Chemicals that *Ruin Other Pumps!*

MOYNO's unique *"progressing cavity"* principle and special resistant internal parts slash pump maintenance costs on problem chemicals that ruin other pumps. Any chemical that can be forced through a pipe—from thin watery slurry to extremely viscous rubber dough—can be pumped with a MOYNO.

As illustrated at right and in the cutaway model above, a rugged screw-like rotor turning inside a double-threaded stator forms *"progressing cavities"* which move chemicals smoothly. Fluids are pumped without turbulence, agitation or pulsation, and discharged uniformly. Rotor and stator materials resist abrasion and corrosion. Hundreds of difficult chemicals successfully handled prove that MOYNOS show little wear, even after long service. They have increased production and greatly lowered downtime on many jobs where they replaced other type pumps which had run up prohibitive maintenance costs or failed completely. On other jobs, MOYNOS have succeeded where chemicals were formerly moved by hand or other expensive means because they were considered unpumpable.

MOYNOS are available in capacities up to 500 gpm; pressures up to 1000 psi. Off-the-shelf replacement parts are always immediately available. To find out how you can decrease chemical pumping costs, write today for Bulletin 40 CE



ROBBINS & MYERS, INC.

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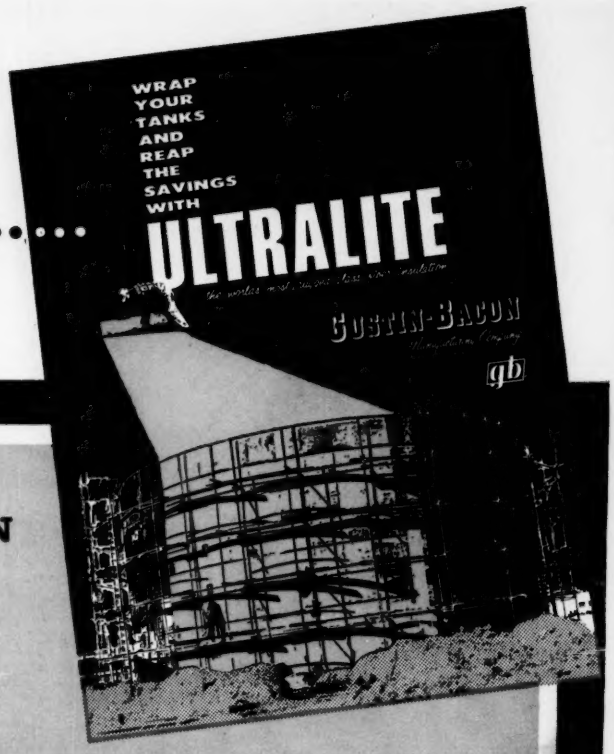
SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

WRITE FOR THIS NEW BROCHURE..... TODAY!



TECHNICAL BULLETIN ON INSULATING HEATED STORAGE TANKS SHOWS YOU . . .

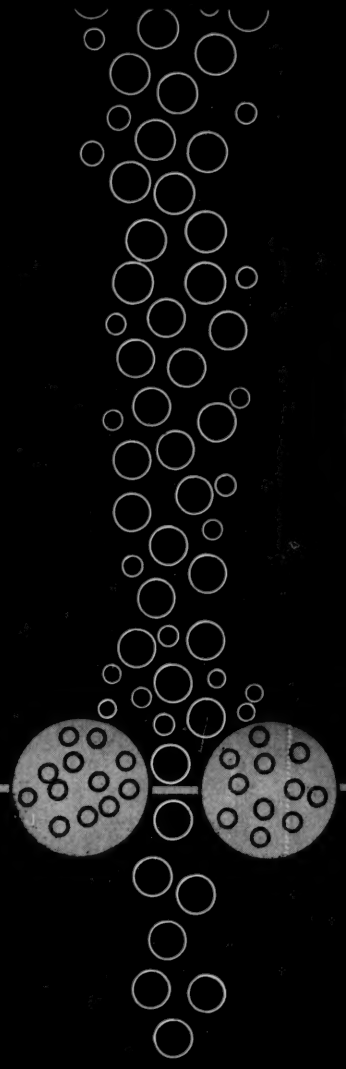
- An easy way to figure how many btu's (and dollars) are now being wasted by your uninsulated tanks, vats and vessels.
- Latest lower-cost techniques of insulating large and small tanks.
- Why ULTRALITE, far more effectively than any other insulation, meets *all* the requirements for permanent and economical tank insulation.
- Why ULTRALITE-insulated tanks usually require *not one penny of maintenance* over the years!
- How ULTRALITE glass fiber insulation literally pays for itself . . . in some cases in just 6 months by saving over 90% of the heat now being wasted!

The new 8-page ULTRALITE Tank Insulation Brochure, we believe, offers the most comprehensive and current information available on the who-what-why-when-and-how of insulating tanks. Your free copy is available for the asking—just write today.

GUSTIN-BACON *Manufacturing Company* gb

252 West 10th St., Kansas City, Mo.

Thermal and acoustical glass fiber insulations . . . Molded glass fiber pipe insulation
Couplings and fittings for plain and grooved end pipe



One-stage purification delivers

ETHYLENE WITH LESS THAN 1PPM OF CO_2

...WHEN YOU ADSORB WITH LINDE MOLECULAR SIEVES

This is only one of many applications which utilize the high capacity and selectivity of LINDE Molecular Sieves. In fact, Molecular Sieves not only outperform other adsorbents, but do other adsorption jobs never before accomplished. Whether in new installations or as replacement adsorbent in existing units, Molecular Sieves can help you minimize both investment and operating costs. More specifically, here's how they are used. . .

A major petrochemical company has reduced the CO_2 content of its ethylene from 3000 PPM to less than 1PPM. This high purity is achieved in a single-stage process, automatic and non-corrosive, which has proved to be more economical than the alternative four-stage process. Other petrochemical uses include drying of cracked gases, ethylene, hydrogen, liquid propylene, solvents and many other gases and liquids. **Natural gas producers** use Molecular Sieves for drying and sweetening of natural gas, for sweetening of liquid propane and butane, and for drying of adsorber oil. **Petroleum refiners** use them to gain efficiency in drying reformer hydrogen, liquid butane LPG and transformer oil, and for removal of impurities such as CO_2 and mercaptans. **Refrigeration manufacturers** use Molecular Sieves as a desiccant in super-drying refrigerants to eliminate freeze-up and corrosion.

For these and many other adsorbent applications, you can rely on patented LINDE Molecular Sieves to perform more effectively. They are the top quality material of their kind available today, always uniform, with high capacity, high strength, and high bulk density. They are available in regular and special grades to meet your specifications.

LINDE technical know-how—gained from years of laboratory and field work with adsorption problems—can help make Molecular Sieves work profitably for you. For further information, write: Dept. CE-063 Linde Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, New York. **In Canada:** Linde Company, Division of Union Carbide Canada Limited, Toronto 7, Canada.

SOME AREAS WHERE MOLECULAR SIEVES IMPROVE ADSORPTION

- Purification of ethylene
- Drying gases, liquids, solvents
- Drying, sweetening natural gas
- Sweetening liquid propane, butane
- Drying jet fuels
- Octane improvement
- As refrigerant desiccant
- Controlled atmosphere purification

LINDE COMPANY

UNION CARBIDE

"Linde" and "Union Carbide" are registered trade marks of Union Carbide Corporation.

CHEMPAC® (WHITE)

THERMOCORE® (BLACK)

Now—just two J-M styles will handle 9 out of 10 mechanical packing problems!

LET VERSATILE "BLACK" OR "WHITE" HELP YOU REDUCE PACKINGS INVENTORY

Of Johns-Manville's many packing styles, two stand out as "all-purpose" packings. One is for pumps, the other for valves. These two packings not only do an outstanding sealing job . . . they also simplify your packings inventory investment to a minimum.

In 9 out of 10 cases, CHEMPAC and THERMOCORE will handle any pump or valve job in your plant!

CHEMPAC (white) combines the excellent sealing and heat-resistant qualities of asbestos . . . with Teflon's immunity to almost all chemical and solvent action. Chempac Style 2009 will give outstanding service on pumps, expansion joints and agitators.

THERMOCORE (black) consists of asbestos yarns, reinforced with Inconel wire . . . braided over a plastic core of graphite and 100% white asbestos. It remains stable even in valves where line temperatures run as high as 1200 F . . . adapts readily to eccentric motion. Thermocore Style 397 is recommended as the "universal" valve packing.

Johns-Manville produces the industry's most complete range of packing styles. These are described in a new 64-page Mechanical Packings book—the most complete of its kind. In its handy pages, you will find answers to the correct selection of packings best suited to each particular requirement.

For full information on "WHITE" and "BLACK," see your J-M Distributor . . . or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ont.

JOHNS-MANVILLE JM PRODUCTS

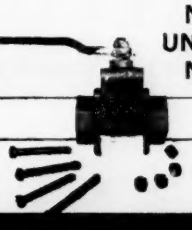
THE ECON-O-MISER BALL VALVE...

The most advanced replacement valve for ON-OFF applications

Engineered design simplicity provides superior performance plus real dollar savings. • Remove 4 bolts—the center section lifts out—unions are eliminated. Service time and cost are reduced to a matter of minutes and pennies, and the valve is right back in operation. Costly spare parts are a thing of the past. • The Econ-O-Miser Ball Valve answers thousands of difficult application problems—simply—efficiently. Available from ¼″ through 6″ size range, it is ideally suited to difficult media, because of its smooth round flow and quarter-turn operation. • If you're interested in valves, you're interested in the Econ-O-Miser Ball Valve. Complete, up-to-date technical information is yours for the asking.

WORCESTER VALVE CO., INC.

16 PARKER STREET, WORCESTER, MASS.



Check these improved
1960 insulations

B E H
BALDWIN-EHRET-HILL

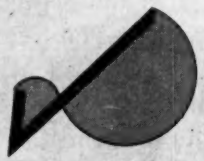
you'll want
them in your new specifications

Take a Fresh Look at **Gem-Foam**

Low Temperature Polyurethane

Here's a new solution to your low temperature insulation problems! B-E-H Gem-Foam helps you maintain operating temperatures of piping and vessels from 275 F down to the lowest commercial temperature. For instance, at a mean of —50 F its conductivity is .09, requiring only half the usual thickness for satisfactory performance. A rigid polyurethane foam with closed cell structure, B-E-H Gem-Foam is extremely light-weight yet strong. Pleasant and easy to handle, it resists breakage in application and shipping . . . cuts cleanly and is not abrasive in application. Unaffected by thermal shock, Gem-Foam also has exceptional resistance to chemicals and corrosive vapors. Gemfil, a companion product, foams in place to insulate valves and fittings quickly and economically.

New and improved insulating products, such as these, reflect the constant research and development conducted by Baldwin-Ehret-Hill to anticipate industry's demands for better performance and more application economies. Before writing your specifications, investigate the B-E-H line of specialized insulations for service from sub-zero to 1900 F. Write for our 1960 catalog or see it in your Sweet's Files.



NOW IS THE TIME TO UPDATE YOUR SPECIFICATIONS WITH . . .

BALDWIN-EHRET-HILL

600 Breunig Ave., Trenton 2, N. J.

THE COMPLETE LINE OF INSULATIONS for use SUB-ZERO TO 1900 F.

CONTRACT APPLICATION SERVICE FROM COAST TO COAST

INGENIOUS MECHANISMS
both Ancient & Modern for the Elevation of Liquids

compiled in commemoration
of
100 YEARS OF PUMP PROGRESS
by
Ingersoll-Rand
Hydraulics Division
1860-1960

MACHINES THAT MAKE
ENGINEERING DREAMS COME TRUE

THE PUMP is one of the *oldest* mechanical devices used by man. And "engineers" from pre-history and the middle ages dreamed-up some ingenious machines for the elevation of liquids. Fourteen of these ancient and medieval devices are illustrated and described in this Anniversary Booklet which traces the development of the pump from its earliest beginnings, and also includes a summary of recent Ingersoll-Rand developments in pumping equipment. For your free copy, just send a letter or post card to Ingersoll-Rand, 11 Broadway, New York 4, N.Y., requesting Bulletin 198. There is no obligation, of course.

A CENTURY 1860 — 1960 OF PUMP PROGRESS

Ingersoll-Rand

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A-B QUALITY

ALLEN-BRADLEY
Solenoid Starters give
MORE MILLIONS OF TROUBLE FREE OPERATIONS

... and for good reasons

• ONE MOVING PART
With this simple solenoid design, there's virtually nothing to go wrong—all trouble-causing bearings, pivots, and flexible jumpers have been eliminated.

• DOUBLE BREAK, SILVER ALLOY CONTACTS
Allen-Bradley silver alloy contacts never require maintenance. They are always in perfect operating condition . . . and remain so until completely worn away.

• SIMPLE UP-AND-DOWN MOTION
The virtually frictionless, straight line vertical motion provides uniform contact pressure at all times—and assures consistent, rapid operation of the contactor.

• RELIABLE OVERLOAD PROTECTION
All A-B starters are equipped with two permanently accurate and reliable overload relays that protect motors against "burnouts." Three overload relays can be furnished.

BULLETIN 709 STARTERS are made in 9 sizes from Size 0 (at left) up to Size 8.

BULLETIN 709 SIZE 7 with maximum ratings of 300 hp, 220 v; 600 hp, 440-550 v.

ALLEN-BRADLEY
QUALITY MOTOR CONTROL

INDUSTRIAL CHEMICALS

ANHYDROUS AMMONIA – This basic industrial chemical is available in commercial and refrigeration grades from three strategically located plants.

AQUA AMMONIA (NH_4OH) – An economical source of nitrogen and an easily handled alkali.

AMMONIUM NITRATE–In pelleted form. Typical analysis: Ammonium Nitrate content – 96% or more.

AMMONIUM NITRATE SOLUTIONS – NFS-83 and NFS-50. Ammonium nitrate-water solutions containing respectively 83% and 50% NH_4NO_3. For explosives, fluid catalysts, pharmaceutical applications.

AMMONIUM SULFATE – Diverse uses include fireproofing, fertilizers, leather tanning.

ETHYLENE OXIDE – Rocket propellant, fumigant, fungicide, chemical intermediate.

ETHYLENE GLYCOL – Also Di- and Tri-. Humectants, plasticizers, scrubbing solutions for gas dehydration, scores of other industrial uses.

ETHANOLAMINES – MEA, DEA, and TEA. Versatile, reactive, easy to handle. TEA available in 98% and commercial grades.

FORMALDEHYDE – Available as 37% Inhibited, 37% Low-Methanol, 45% Low-Methanol. 50% Low-Methanol.

METHANOL – 99.85% pure. In barge, tank car, and tank-truck quantities.

NITROGEN TETROXIDE – High energy oxidant for liquid rocket propellants. Easy to handle and store.

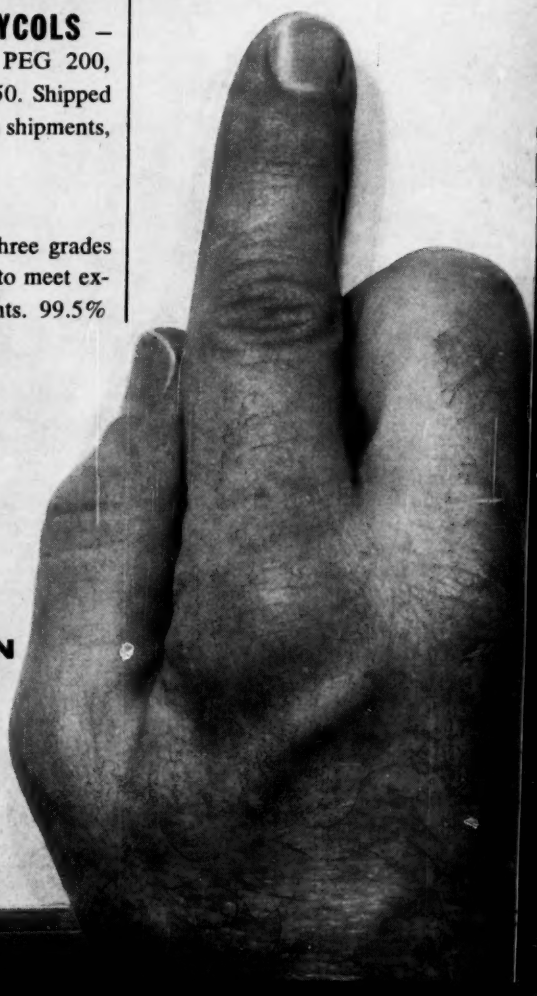
POLYETHYLENE GLYCOLS – Available in six forms: PEG 200, 300, 400, 600, 1000, 1450. Shipped in tank car or combination shipments, tankwagon and drums.

SODIUM NITRATE – Three grades – coarse, medium, fine – to meet exacting process requirements. 99.5% pure.

UREA – Multiplant production assures unfailing supply of this basic chemical in crystal and pelleted form.

U-F CONCENTRATE-85 – Highly concentrated solution of urea (25%) and formaldehyde (60%). Easy to handle, economical source of these materials for resins and adhesives.

For specifications and local offices, see our insert in Chemical Materials Catalog, pages 475-482 and in Chemical Week Buyers Guide, pages 37-44.



BASIC TO AMERICA'S PROGRESS

Allied Chemical

NITROGEN DIVISION

Dept. AP 10-5-1, 40 Rector Street
New York 6, New York

2819

Cost-cutting step taken 26 years ago still paying off at Hamm Brewery —they chose NONPAREIL Turbine Oil

Situation: In 1934 the Theo. Hamm Brewing Company installed two 1,000 kw. turbines. The brewing firm wanted to be sure there would be no downtime due to failure of the lubricant. Neither did the company want to spend time checking the oil's performance or adding new oil to sweeten the old.

What was done: Brewery management followed the advice of the Standard Oil lubrication specialist. They installed NONPAREIL Turbine Oil, the only oil, then as now, that carries with each fill a life-of-turbine guarantee.

What has happened: In 26 years since the turbines were put in service there has never been any downtime due to lubrication problems. In 1947 a 2500 kw. turbine was added to the system and another 3000 kw. unit was put in service in 1953. These, too, have used NONPAREIL Turbine Oil with the same results.

What you can do: Get the full story on NONPAREIL Turbine Oil from the Standard Oil office near you in any of the 15 Midwest and Rocky Mountain states. Or write **Standard Oil Company (Indiana), 910 South Michigan Avenue, Chicago 80, Illinois.**

Quick facts about **NONPAREIL Turbine Oil**

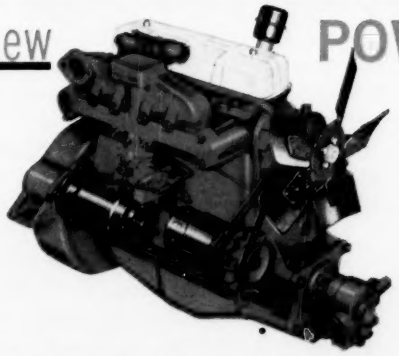
- Will not permit formation of harmful acids
- Will not permit formation of sludge or oil varnish
- Will maintain good demulsibility or water separating characteristics
- Has high resistance to foaming
- Contains adequate rust inhibitor

You expect more from **STANDARD** *and you get it!*

Hamm Brewing Co. assistant chief engineer Steve Wappel and Standard's Dick Anderson discuss recent oil analysis. Dick Anderson knows his way about an industrial power plant. He's been providing customers with technical service on lubrication for five years. Dick has an engineering degree from the University of Minnesota and has completed the Standard Oil Sales Engineering School.

3 NEW F series
ALLIS-CHALMERS LIFT TRUCKS

with new POWER-CRATER engine



Unique crater-shaped piston head in POWER-CRATER engine, built by Allis-Chalmers, sets up violent swirling turbulence, thoroughly mixing fuel and air. Because of this proper mixing, a higher percentage of fuel is transformed into useful energy. Thus, Allis-Chalmers F series lift trucks effect substantial savings in fuel.

POWER-CRATER and POWER-SHIFT are Allis-Chalmers trademarks.

Outstanding working ability and convenience

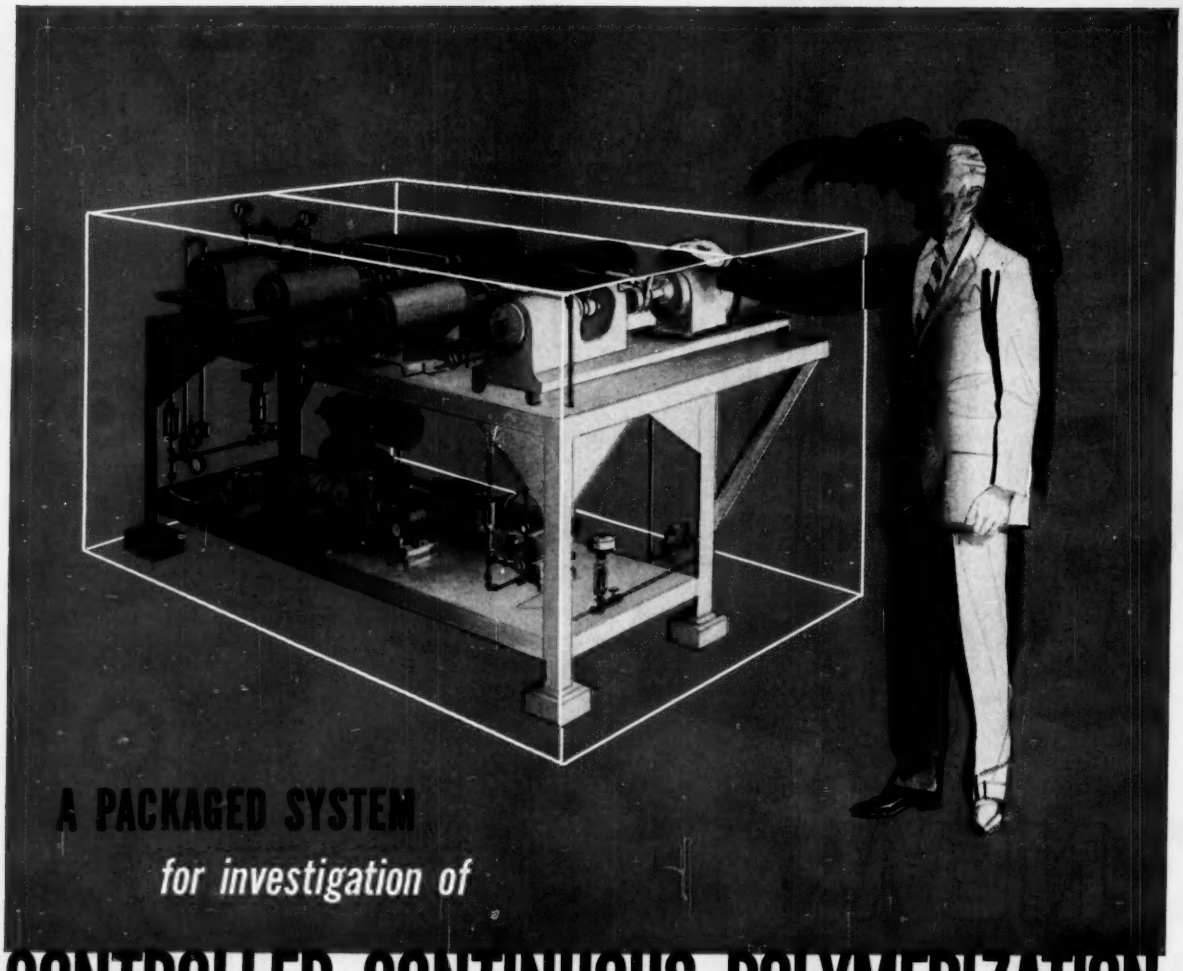
- Power, balance and weight distribution to climb steep grades
- Roller channel steel masts for smooth, fast lifting
- Simple, "easy-to-turn" steering, one-lever gear shift
- Pivoted steer axle for smoother riding, positive traction
- Comfortably wide, adjustable, ventilated-cushion seat
- Familiar automotive-type controls, key starting switch
- Positive, safe braking — two systems: large two-directional hydraulic brake, mechanical parking brake
- Solid 2" x 5" bar-steel, heavy-duty frame—foundation for long life and dependability
- Easy serviceability—seat tilts up for easy access to engine, clutch change in only 30 minutes, counterweight quickly removed
- Replaceable wet cylinder liners in engine save time and money
- Optional transmissions — standard or POWER-SHIFT drive

Let your dealer show you how new F series trucks *do more, save more.*
Send for new bulletin BU-640. Allis-Chalmers, Milwaukee 1, Wisconsin

BH-142

ALLIS-CHALMERS

POWER FOR A GROWING WORLD



A PACKAGED SYSTEM

for investigation of

CONTROLLED CONTINUOUS POLYMERIZATION

VOTATOR* processing equipment is used for continuous polymerization reactions in numerous installations. It affords fast, efficient, controlled processing not possible in batch reactors.

Girdler's experienced engineers operate extensive pilot facilities to provide exact specifications for scaling up to production equipment. VOTATOR engineered systems are designed to meet your own specific process requirements. These systems provide a high degree of flexibility and versatility. They save materials, use less floor space and assure significant overall operating economy.

Rugged, dependable VOTATOR continuous reactors are fabricated by skilled craftsmen in strict compliance with ASME codes. Materials of construction are carefully selected according to the properties of products processed.

Packaged VOTATOR pilot systems are now available for studies of continuous reaction processes in your plant. For additional information write Girdler Process Equipment Division, P.O. Box 43, Louisville 1, Kentucky.

*VOTATOR—Reg. U. S. Pat. Off.

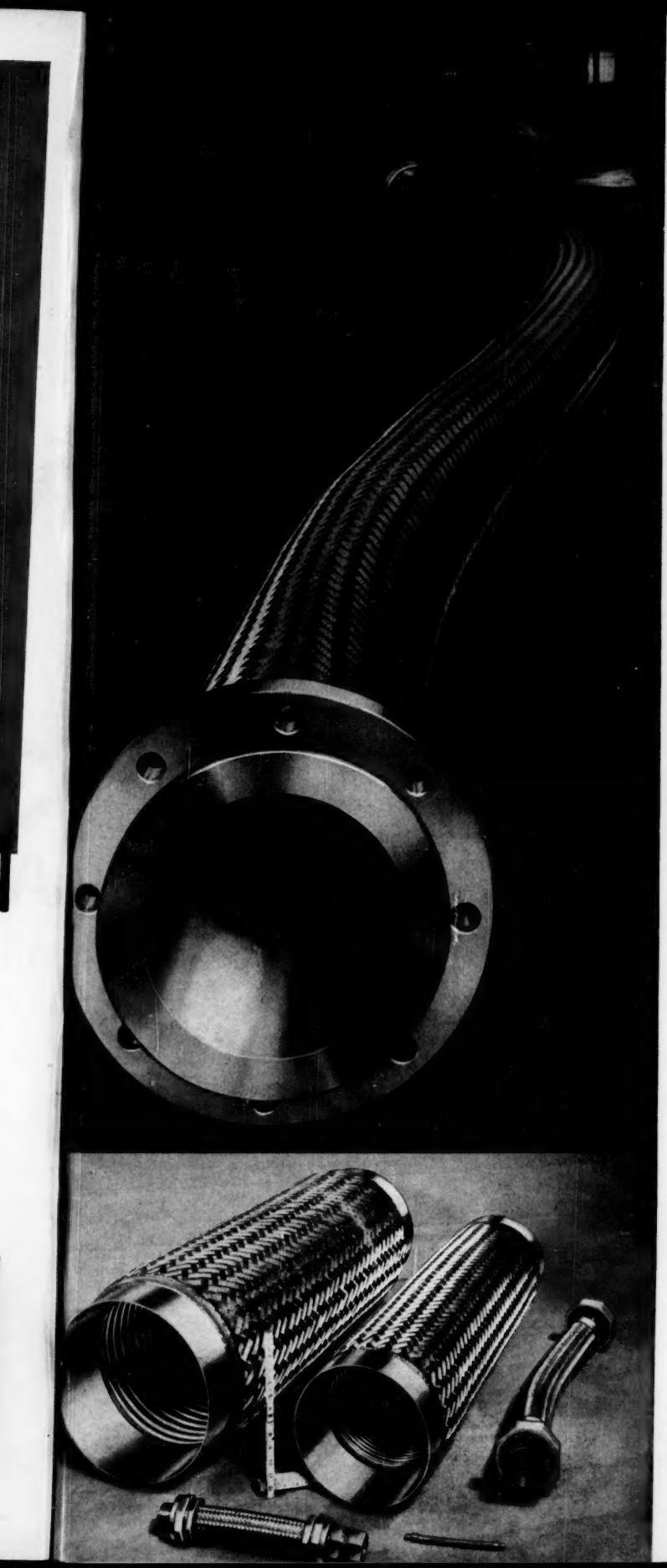
GIRDLER PROCESS EQUIPMENT DIVISION

CHEMETRON CORPORATION

Louisville 1, Kentucky

CHEMETRON

VOTATOR CONTINUOUS PROCESSING EQUIPMENT FOR CHEMICAL & FOOD INDUSTRIES • VOTATOR PISTON & GRAVITY FILLERS • VOTATOR PLANTS FOR FATTY OILS INDUSTRY • THERMEX DIELECTRIC HEATING EQUIPMENT



BIG OR SMALL

FLEXIBLE TUBING ANSWERS TO TOUGH PROBLEMS

The flexible metal tubing assemblies on this page give an indication of the scope of facilities at Anaconda Metal Hose for designing and manufacturing tubing answers to tough problems.

The big 16½-foot, 8-inch diameter tube in stainless steel at the left was built for handling liquid oxygen in missile ground handling equipment. In the photo below, left rear, are two stainless steel connector assemblies—14-inch and 10-inch I.D.—also used in handling liquid oxygen.

From such assemblies down to the tiny ⅛-inch I.D. Vibration Eliminator shown in the foreground at the bottom of the page, the variety of flexible hose assemblies—in size, material, and design—is almost infinite.

FREE TECHNICAL SERVICE. Anaconda Metal Hose specialists are constantly working with design engineers on special flexible connectors and hose to meet new problems. Having broad experience working in stainless steel, other steel alloys, Monel, copper alloys, aluminum, and Teflon,* they can save you considerable time and money in designing the flexible connector best suited for your needs.

Our specialists are available to you through Anaconda Metal Hose representatives in leading cities — see listing "Metal Hose" in the Yellow Pages. Or write: Anaconda Metal Hose Division, The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont. *Registered trademark for Du Pont fluorocarbon resins.

59130

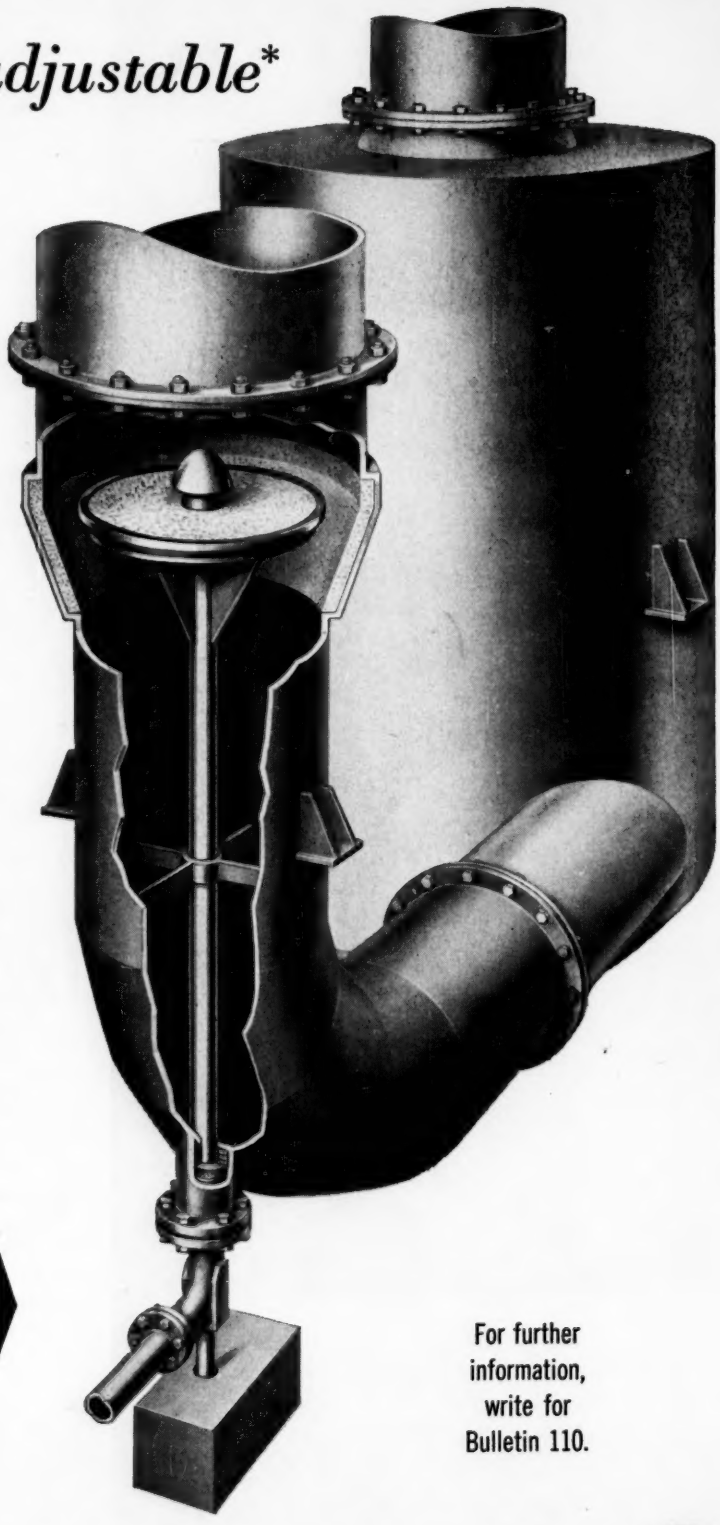
ANACONDA®

METAL HOSE

*Completely adjustable**

Flooded Disc Scrubber

Removes Sub-Micron Fumes



The Research-Cottrell high efficiency scrubber uses the unique flooded disc principle for removing sub-micron fumes in steel-making furnaces and chemical processing.

As shown in the illustration, the outstanding feature of this scrubber is the simple, adjustable "flooded disc." The flooded disc adjusts for maximum cleaning efficiency over a wide range of operating conditions.

* *Automatic positioner immediately adjusts the disc to meet your varying gas and dust control problems.*

Research-Cottrell, with over 48 years of industrial gas cleaning experience, will be glad to consult with you on any specific problem.

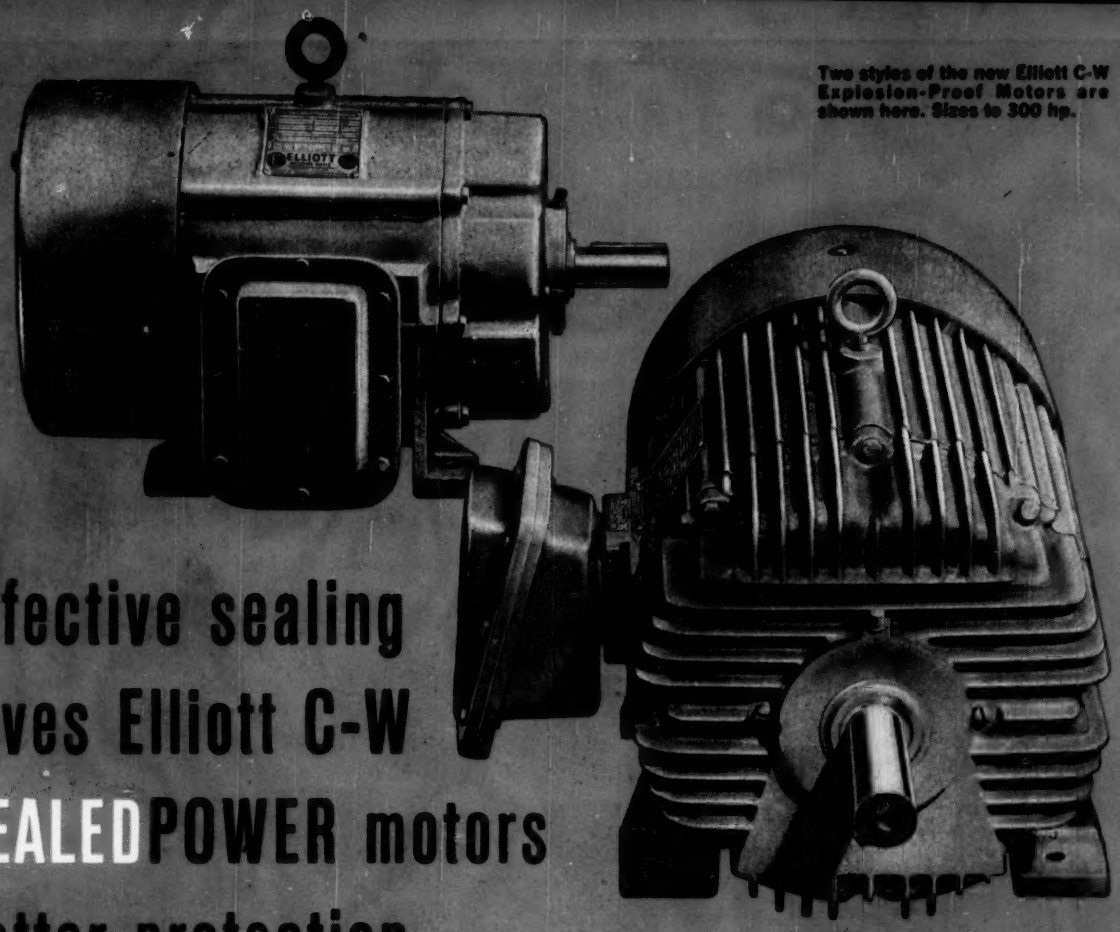
For further information, write for Bulletin 110.

Research-Cottrell

RESEARCH-COTTRELL, INC., Main Office and Plant: Bound Brook, N. J.
Representatives in principal cities of U.S. and Canada

COTTRELL TRADE MARK

RC107



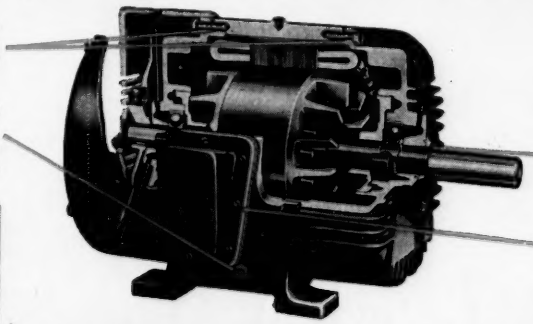
Two styles of the new Elliott C-W Explosion-Proof Motors are shown here. Sizes to 300 hp.

effective sealing gives Elliott C-W SEALEDPOWER motors better protection against moisture, dust, fumes, corrosion

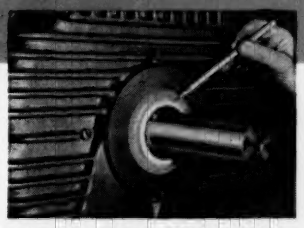
LONG, SNUG BRACKET SEAL. Close-fitting, deep rabbet provides explosion-proof type seal for all SEALEDPOWER motors.

EASILY ACCESSIBLE, automatic breather and drain plug, underwriters approved, for removing internal moisture accumulations.

NEW DATA on the complete line of Elliott C-W SEALEDPOWER motors is given in Elliott Bulletin PB 6000-2. Send for free copy today.

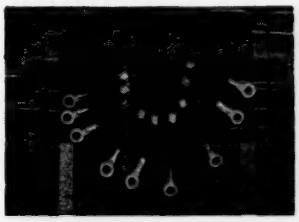


Elliott explosion-proof motor—underwriters approved.



ROTATING SLINGER PREVENTS entrance of dirt and moisture through the bearing and shaft opening.

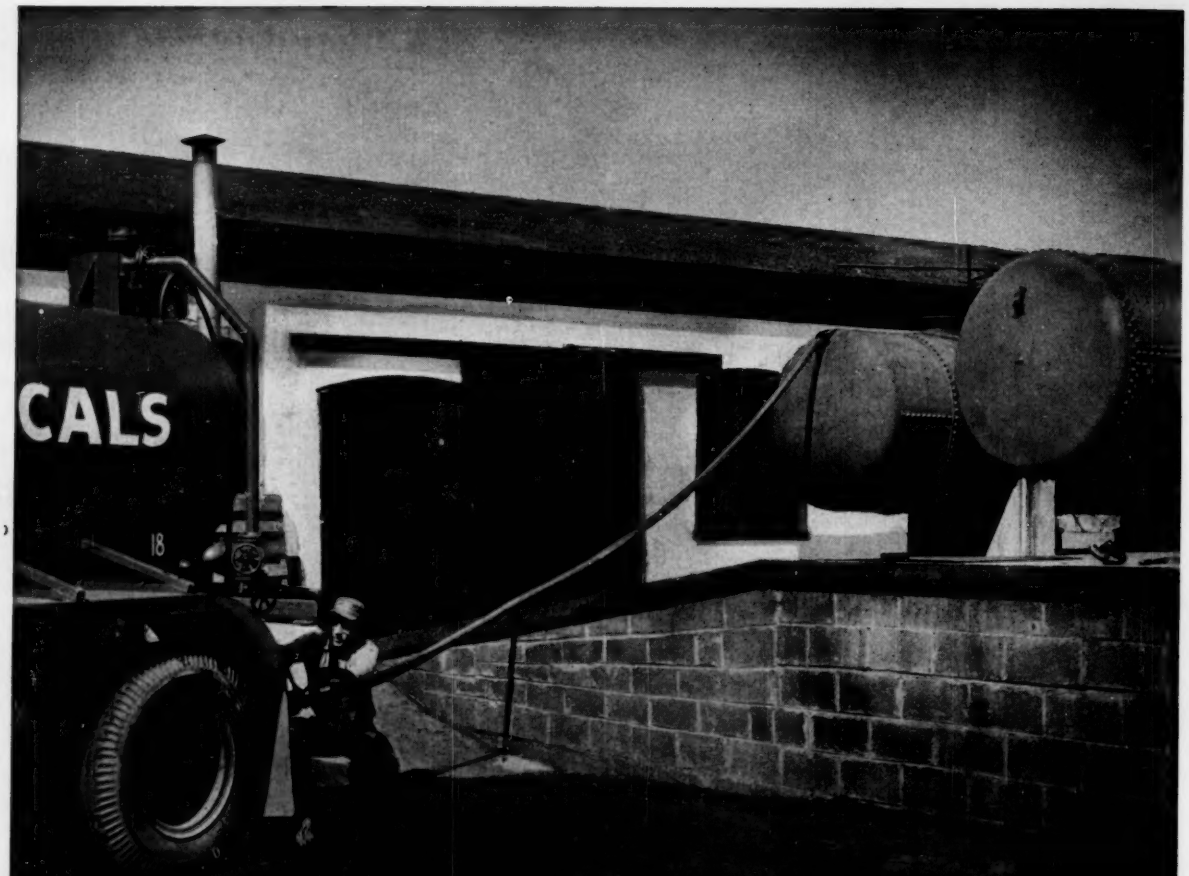
NO LEAKAGE HERE. Tightly sealed leads and opening. Metal-to-metal fit between conduit box, frame and cover.



ELLIOTT Company

Crocker-Wheeler Plant Jeannette, Pa.

W 9 3



Better than any other acid hose we've ever used

After handling many makes of acid hose the chemical operator at this plant has found that Acme-Hamilton acid discharge hose is outlasting the others, remains flexible even when cold, and is highly resistant to weathering. This A-H hose has been in service 2 years conveying 2,000 gallons of commercial sulphuric acid per week.

Acid Discharge Hose

(A) Cover. Tough abrasion and acid resistant rubber. Hose ends are rubber sealed.

(B) Carcass. Multiple fabric plies withstand pumping pressures, provide high degree of flexibility.

(C) Tube. Pure gum; will handle wide range of acids, salts and alkalis. (Can also be furnished with Hypalon* tube for special applications.)

Write Dept. C-1. *Du Pont T. M.

Acme Hamilton

MANUFACTURING CORPORATION, TRENTON 3, N. J.

Divisions: Acme Rubber Mfg. Co. • Hamilton Rubber Mfg. Corp.

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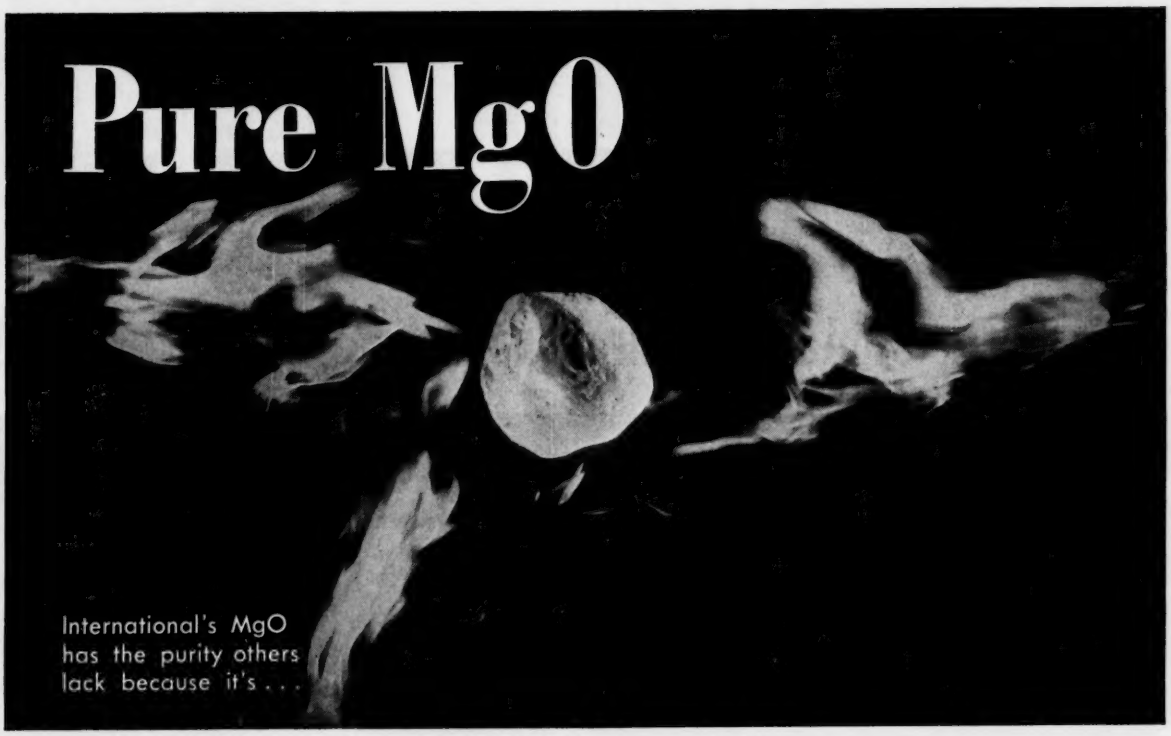
Pure MgO



produced by thermal decomposition

Disappointed with conventional magnesium oxides? Then try International's. *It's the only MgO produced by thermal decomposition.* And the difference is amazing! Electrically furnaced, this MgO has achieved the highest resistivity and refractory properties of any commercially available magnesium oxide.

You'll find International MgO relatively low in cost. Now improved production facilities are geared to produce any quantity you need.

For further details, fill out and mail the coupon . . . you can count on a prompt reply.

Here's how IMC does it!

CONVENTIONAL PROCESSES

↓

Magnesium Chloride $MgCl_2$
(Contained in sea water, well brine, bittern.)

+

Lime CaO
(Contained in dolomite, sea shells, etc.)

↓

Magnesium Hydroxide $Mg(OH)_2$ + heat

↓

Magnesium Oxide MgO

INTERNATIONAL'S UNPARALLELED PROCESS

Magnesium Chloride $MgCl_2$ + heat

↓

Magnesium Oxide MgO + Hydrochloric Acid HCl

↓

heat → MgO

And here's the result!

MgO	99.5%	Cl	0.03	Density .... 75 lbs./cu. ft.*
S_iO_2	Nil	CaO	0.05	*Low Boron, too, upon request!*
SO_4	0.03	Fe_2O_3	0.05	

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☐ POWDERED MgO ☐ GRANULAR MgO ☐ PELLETIZED MgO

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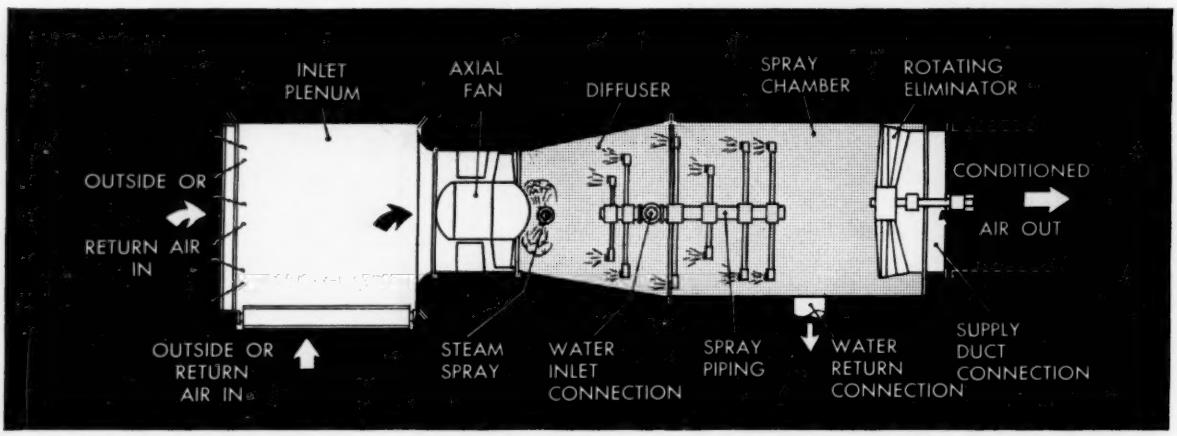
41-59

NO AIR FILTERS?
NO AIR FILTERS!

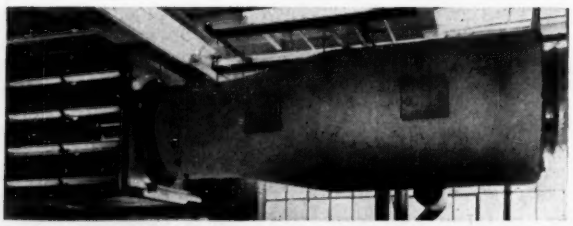
This Carrier Rotaspray Air Conditioner is self-cleaning!



Rotaspray units are self-cleaning and require no filters. Instead of trying to keep dust and coarse particles out as conventional systems do, the Carrier unit lets them enter, separates them from the air and returns them to a central point for automatic collection disposal.

As important as the self-cleaning feature is, it's only one of many ways the Carrier Rotaspray Weathermaker System* has proved itself vastly superior to conventional close-control air conditioning systems. For example:

UNITARY DESIGN. Instead of one large conventional central station system serving several departments, each department has its own Rotaspray unit and can change its temperature and humidity to meet its individual needs.



Carrier Rotaspray Weathermaker units may be installed rooftop mounted, ceiling suspended or outside wall mounted.

SMALLER APPARATUS SIZE. A Rotaspray unit requires less than 1/3 the space of a conventional system of equal capacity.

ELIMINATES MANY SYSTEM COMPONENTS. Units require no water strainer, water pump, water tanks, city water or drain piping. No apparatus room and no floor drains needed.

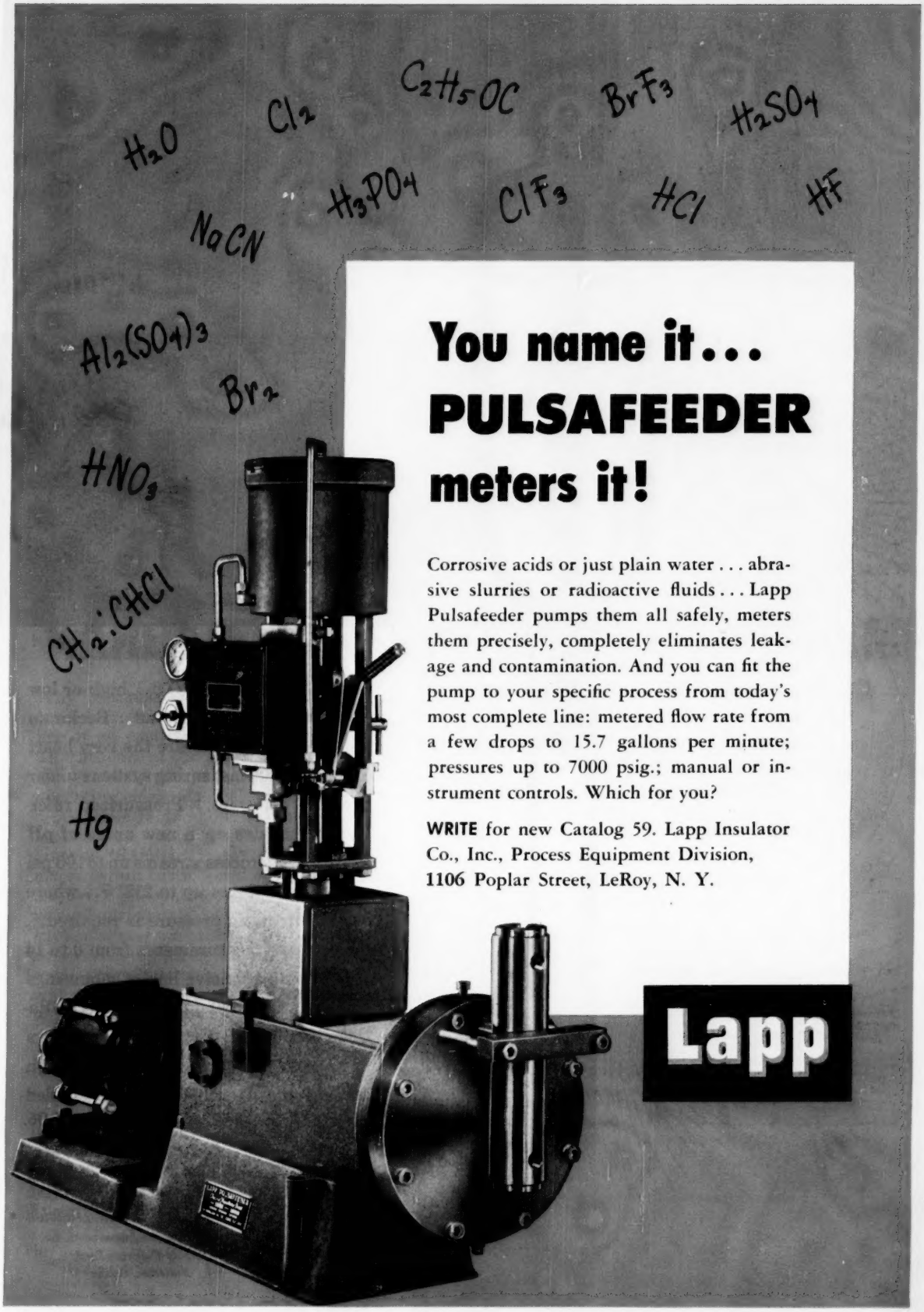
BETTER HUMIDITY AND TEMPERATURE CONTROL. Eliminates dew point control and its problems. Within Rotaspray System capacity, departments simply "dial" the temperature and humidity required.

In all, there are 17 reasons why it's well worth your while to look into the Carrier Rotaspray System for your plant or process. They range from lower installation costs to superior efficiency and substantial savings in operation and maintenance. For information, write Machinery and Systems Division, Carrier Corporation, Syracuse 1, N. Y.

* Reg. U.S. Pat. Off.

BETTER AIR CONDITIONING FOR EVERYBODY EVERYWHERE

Carrier


H_2O
Cl_2
C_2H_5OC
BrF_3
H_2SO_4
H_3PO_4
NaCN
ClF_3
HCl
HF
$Al_2(SO_4)_3$
Br_2
HNO_3
$CH_2:CHCl$
Hg
You name it...
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meters it!
Corrosive acids or just plain water . . . abrasive slurries or radioactive fluids . . . Lapp Pulsafeeder pumps them all safely, meters them precisely, completely eliminates leakage and contamination. And you can fit the pump to your specific process from today's most complete line: metered flow rate from a few drops to 15.7 gallons per minute; pressures up to 7000 psig.; manual or instrument controls. Which for you?
WRITE for new Catalog 59. Lapp Insulator Co., Inc., Process Equipment Division, 1106 Poplar Street, LeRoy, N. Y.
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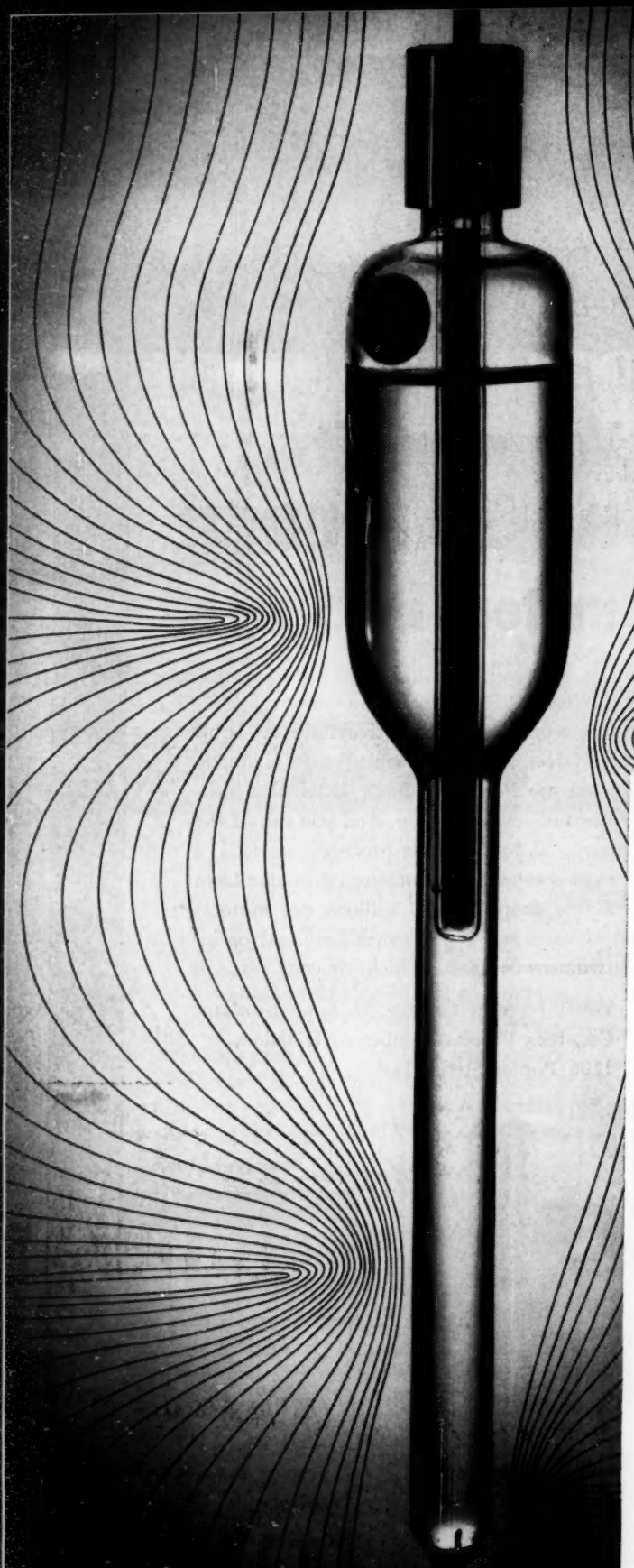

pH under pressure...high or low pressure, hydrostatic head...Beckman Reference Electrodes are the very heart of superior pH measuring systems *under pressure extremes.* ⌘ Pressurized reference electrodes open new areas of pH control...in process streams up to 100 psi ...at temperatures up to 212° F...where only hydrostatic pressure is required... for accurate measurements from 0 to 14 pH. A comprehensive line of mountings offers a variety of pH system installations. ⌘ Beckman pH accessories, meters and electrodes are available through leading recorder companies. For detailed information write for Data File 14-25-06.

Beckman
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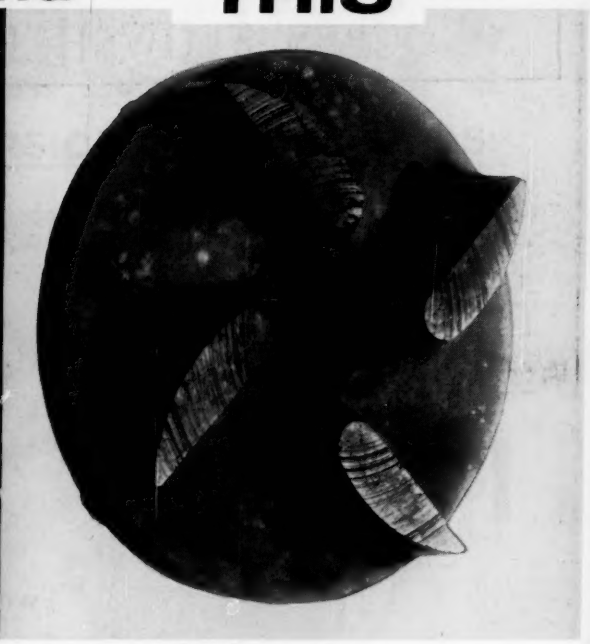
It's a Fact: Three separate plug-in components in the Model W Industrial pH Meter allow easy, quick maintenance, even by untrained personnel.

THE DIFFERENCE BETWEEN THIS and THIS



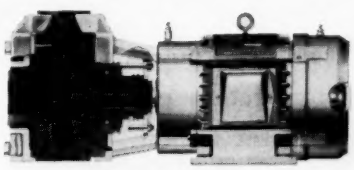
is a corrosion-resistant
"KARBATE" IMPERVIOUS GRAPHITE PUMP!

Why? Because "Karbate" impervious graphite offers total corrosion resistance. It does not rely on a coating or an easily abraded passive or protective film. This absence of corrosion wear in "Karbate" impervious graphite pumps provides continuous, maximum operating efficiency in all recommended applications.

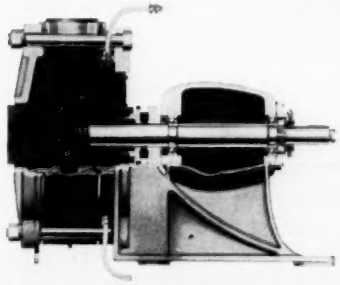
As these facts show, few other pumps — regardless of price — can handle as wide a variety of corrosives as "Karbate" impervious graphite pumps. They are resistant to: *mineral acids* such as *hydrochloric, sulfuric, phosphoric; acid combinations* such as *nitric-hydrofluoric, phosphoric-sulfuric; chlorinated hydrocarbons; alkalies; and organic* and *inorganic compounds of all types.* In practically all of these corrosives, changes in temperature and concentration will not affect the corrosion resistance of "Karbate" impervious graphite.

A "Karbate" pump user comments, "We installed these pumps because they could handle our present variety of solutions and would resist any additional corrosive effects of future changes in these solutions".

In addition to excellent corrosion resistance, these pumps are rugged in construction . . . low in cost . . . and are readily available from stock in a wide variety of models and sizes. **You can pay more but you can't buy a better corrosion resistant pump.** Write for pump literature today!



TYPE F MOTOR-MOUNTED "KARBATE" CENTRIFUGAL PUMP
Cross-section illustrates typical "Karbate" motor-mounted pump recommended for heads to 70 feet — capacities to 140 gpm.



TYPE C FRAME-MOUNTED "KARBATE" CENTRIFUGAL PUMP
Cross-section shows typical "Karbate" frame-mounted pump recommended for heads to 120 feet — capacities to 1500 gpm.

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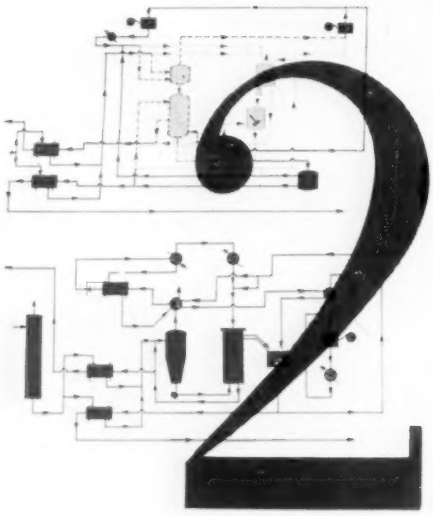


Two Contending
Refrigeration Routes for . . .

Making Fresh Water From Salt Water

Recent government decision—that its final saline-conversion demonstration plant will use a freeze flowsheet—spotlights two leading candidates to join desalting processes now in fold.

One way to extract fresh water from the sea is to refrigerate sea water, then wash and melt the ice crystals that form. This procedure recently became news (*Chem. Eng.*, Apr. 4, 1960, p. 65), when Dept. of the Interior announced that a refrigeration process will be used in the fifth (and final) government-sponsored demonstration plant for saline water conversion. With no specific flowsheet picked yet, two promising freeze-processes appear likeliest to win the nod for the new plant.

In one process, which Carrier Corp. has been studying in a 15,000-gpd. pilot unit, the saline feed itself provides refrigeration when part of it is flashed at very low pressure. In the other method, a development of Cornell's H. F. Wiegandt and the Blaw-Knox Co., butane refrigerant is vaporized in direct contact with the feed. Blaw-Knox will start testing this process in a 35,000-gpd. pilot plant around Oct. 1.

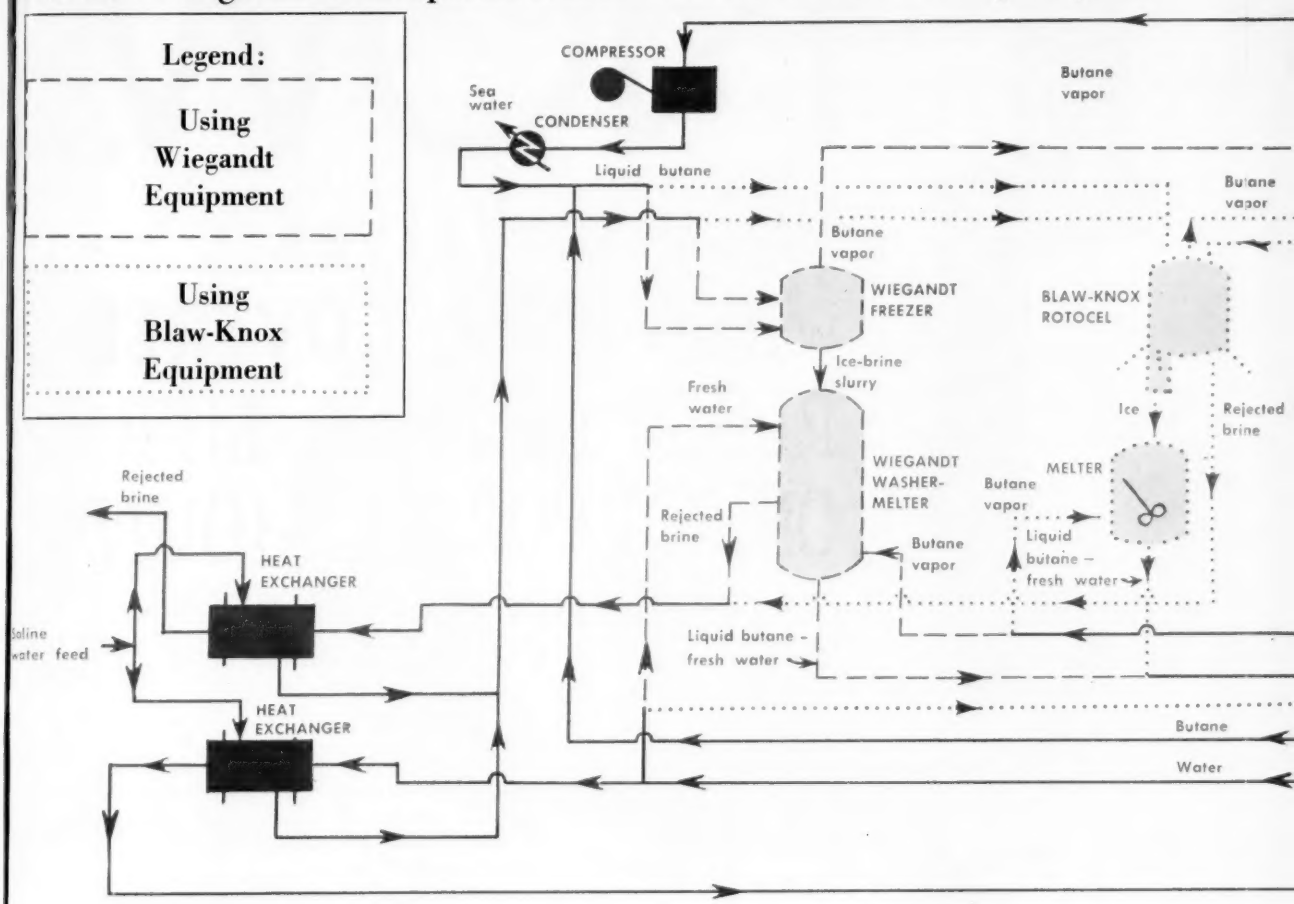
▶ **Cosmopolitan Group**—Output of the freeze-process demonstration plant is to be around 100,000-350,000 gpd. When it is built—probably on the East Coast—it will round out a varied list of government-sponsored conversion plants. None have been erected yet, but processes for the other four are essentially firm.

Purpose of each plant is to provide cost data on semi-commercial-scale conversion of sea or brackish water to fresh water. Such data will help determine if fully commercial conversion for well under $1/1,000 gal. is feasible.

The first plant, to be built at Freeport, Tex., will make 1 million gpd. product water in a multistage long-tube-vertical evaporator system. Next in line is a multistage flash evaporation unit, also to yield 1 million gpd., tentatively set for a California coast site. It will probably use an atomic reactor as heat source. Both of these plants are

Unfold Flowsheet

Butane Refrigerant will vaporize at around 1 atm. in Blaw-Knox pilot plant.



near the construction stage; both will process sea water.

Two other units, further behind in their development, will treat brackish water at inland locations. A 250,000-gpd. electrodialysis plant will be erected at Webster, S. D., and a unit of the same capacity at Roswell, N. M., will use a forced-circulation vapor-compression system.

► **Freezing: Pro & Con**—Use of freezing for saline conversion has several inherent advantages. Energy transfer is a fraction of that which the evaporation processes require—a pound of water will freeze if about 144 Btu.'s are removed from it, whereas over 970 Btu.'s must be supplied to evaporate it. And low operating temperatures keep scale-formation problems to a minimum.

On the debit side, a plant using a freeze process must handle a solid phase. It also faces a difficult separation problem—washing product ice free of unfrozen brine.

► **They Are Alike**—The processes used by Carrier and Blaw-Knox share these advantages and drawbacks, and they resemble each other in overall pattern of operation. Saline feed is chilled by heat exchange with product fresh water and rejected brine, then is partially frozen. The freezing step produces overhead vapor, which is removed and processed, and a slurry of ice in brine.

The slurry goes to a washing device, where brine is drained off and the ice is washed as it countercurrently contacts recycled fresh water. The spent wash stream helps chill incoming feed, then leaves the plant as rejected brine.

The washed ice goes to a melter. Part of the melter output is drawn off as plant product; part is recycled for process use.

An auxiliary heat-removal system, cooling one of the process streams, makes up for plant inefficiencies.

► **Yet Different**—Big difference in the processes, other tha
ing and
operates
pressure-
About 0.5
removing
freezing

The
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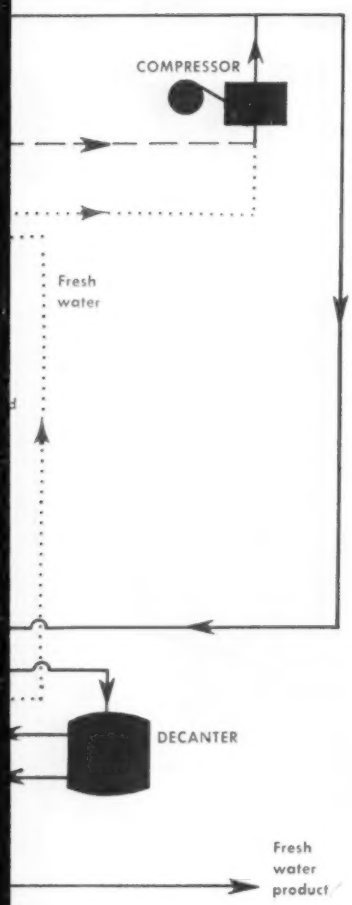
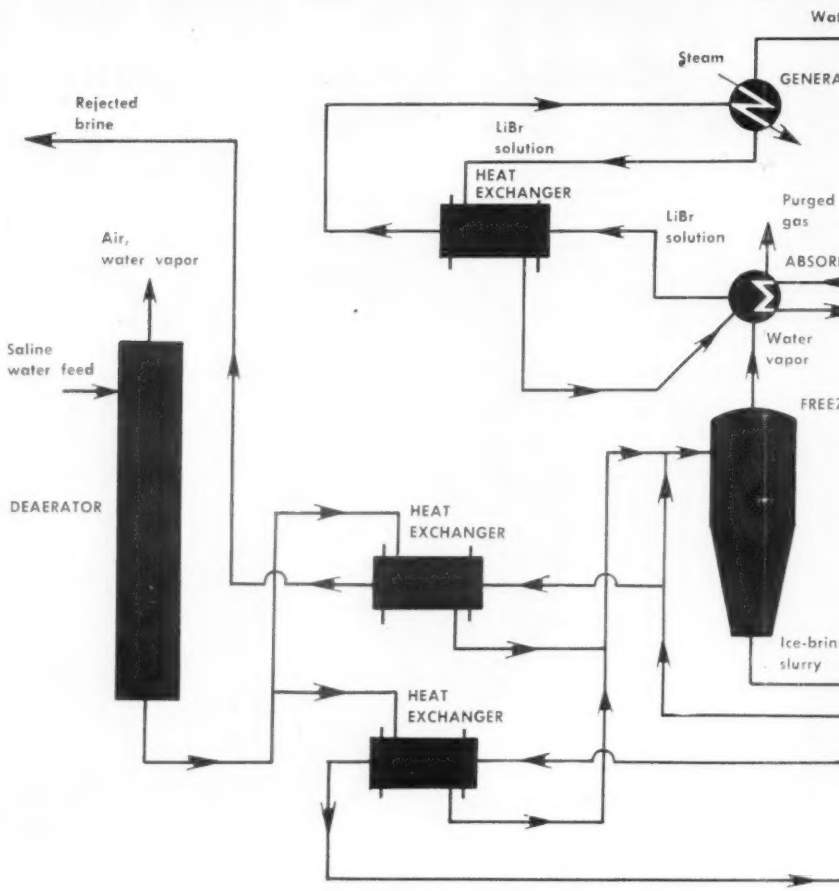
Vacuum Flash, absence of refrigerant, characterize





…han design of equipment, lies in the freez- vapor-handling steps. The Carrier plant …s its freezing chamber at very low absolute …e—about 3 mm. Hg. No refrigerant is used. …5% of the feed vaporizes in the chamber, …g heat from the rest and thus partially … it.

…e low-pressure vapor goes to a modified …on-refrigeration unit. A concentrated LiBr … absorbs the vapor, and after heat ex- …the resulting dilute solution is boiled to …the vapor. It is then condensed and com- …ith recycle from the melter to serve as …uid for ice. Some spent wash is recycled to …zer.

…nwhile, the slurry from the freezer goes …ttom of a column for brine separation and …ing. The ice travels upward, and from the …e column it is scraped into a chute leading …gitated melt tank. Recycled fresh water, which has been warmed by removing heat of solution in the vapor-absorption step, melts the ice.

► **Two Sub-Routes**—Blaw-Knox's plant will form ice by vaporizing butane (or isobutane) in direct contact with the feed, at near-atmospheric pressure. The butane vapor will be compressed, and part of it will contact ice in the melter, thereby condensing as it melts the ice.

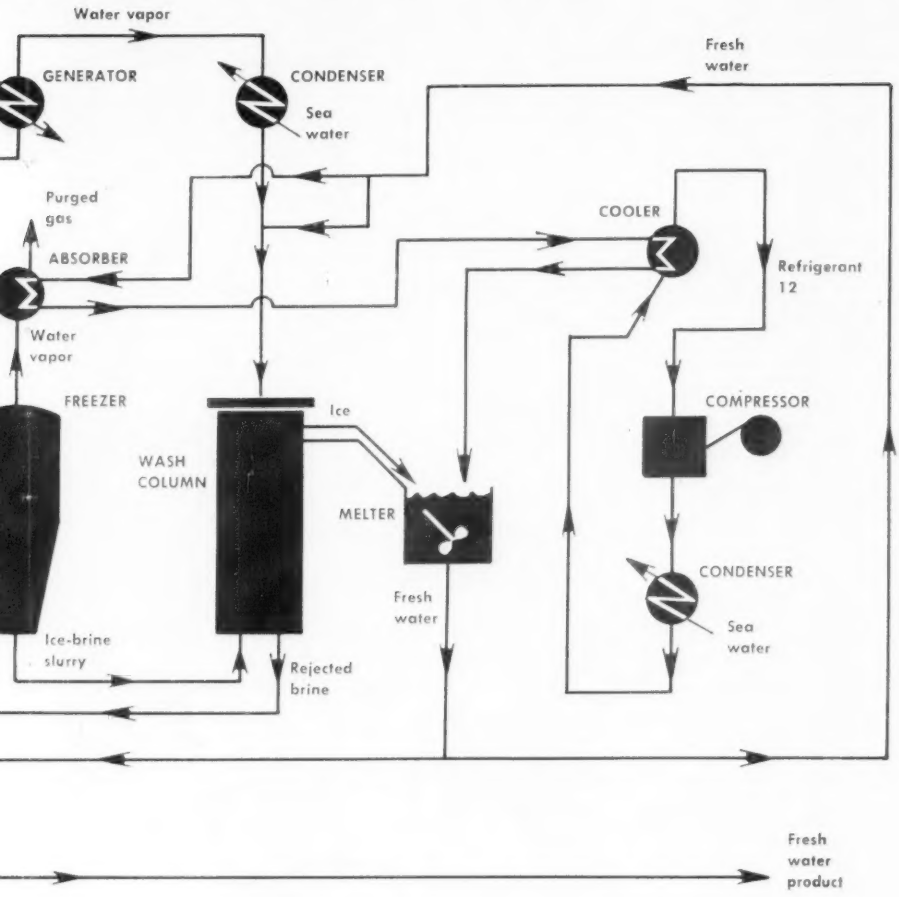
The company will experiment with two distinct freezer-washer-melter arrangements. One, developed by Wieg… …ber mounted abov… other arrangemen… tractor, a rotating… washing, and an a…

Output from… fresh water and b… in a decanter. Bl… treatment for the… add equipment to …

Government-Sponsored Fresh-Water Plants Already in the Wo…

Location	Output (gpd.)	Process	Status
Freeport, Tex.	1,000,000	Long-tube-vertical evaporation	Construction
West Coast	1,000,000	Flash distillation	Construction
Webster, S.D.	250,000	Electrodialysis	Governmen… struction
Roswell, N.M.	250,000	Forced-circulation vapor-compression	Funds for … available

cterize freeze step in Carrier unit.



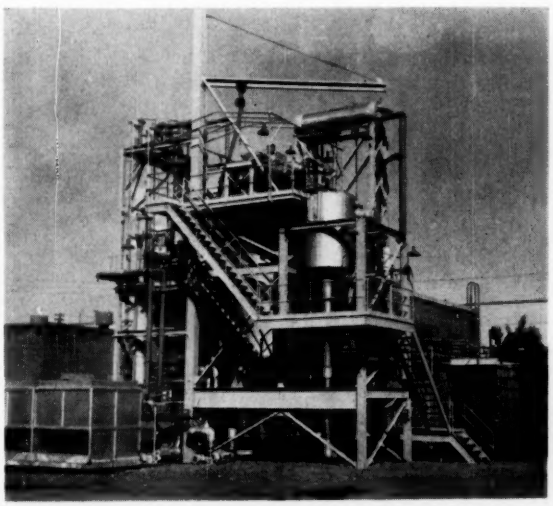
d by Wiegandt, consists of a freeze cham-nted above a washer-melter column. The rangement uses Blaw-Knox's Rotocel ex-a rotating-basket device, for freezing and , and an agitated tank for melting.

put from either melter—a mixture of ater and liquid butane—will be separated canter. Blaw-Knox plans no downstream nt for the water initially, but may later pment to remove any butane traces.

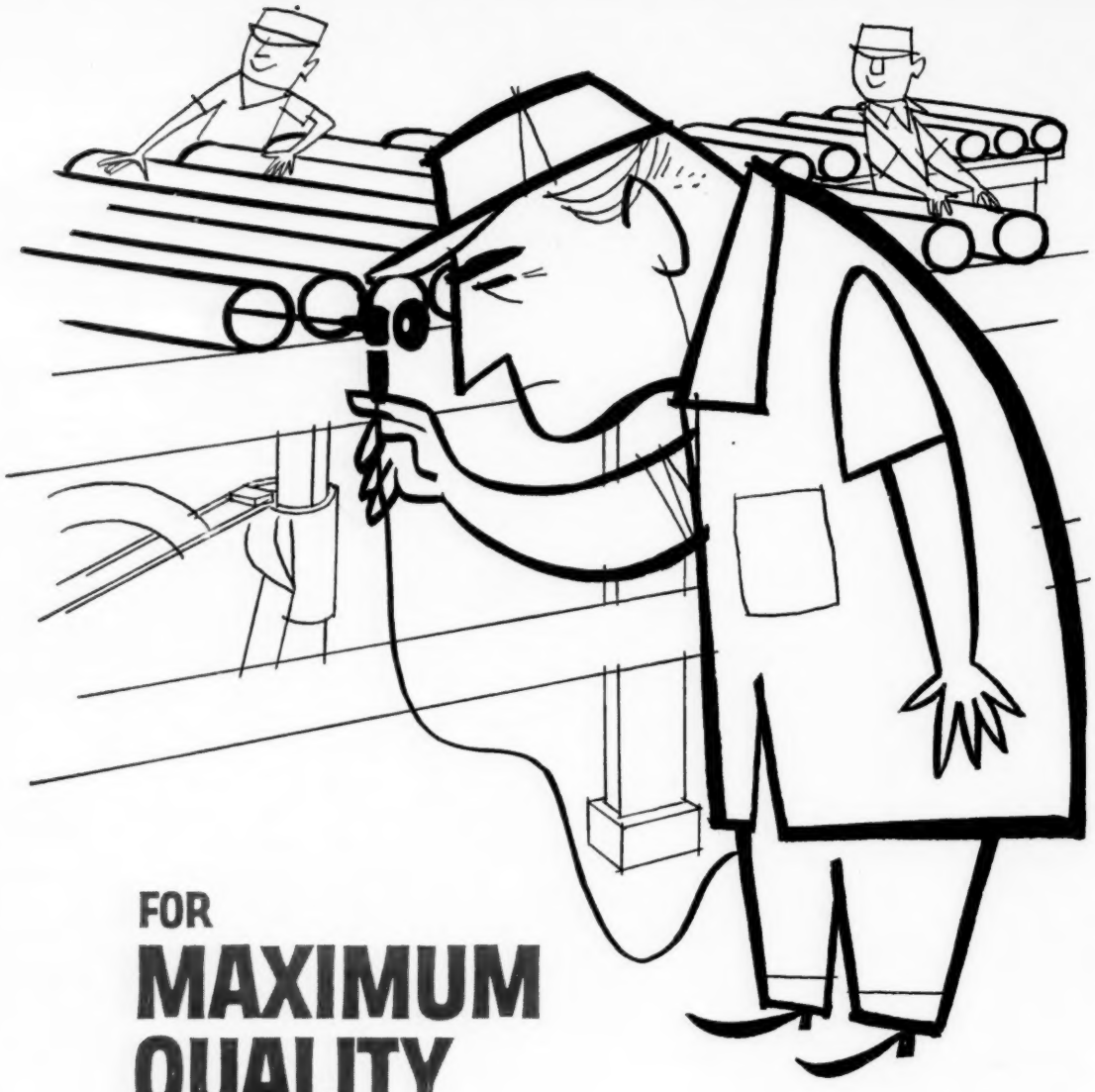
n the Works

Status

- Construction contract awarded this month.
- Construction bidding awaits site selection.
- Government is checking design specs, will let construction bids this summer.
- Funds for architectural and engineering design available this summer.



CARRIER's Syracuse, N. Y., pilot plant makes 15,000 gpd. fresh water. Company will soon move it to a seacoast site.



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B&W *Job-Matched stainless tubing*

B&W offers you . . .

- the stainless tube properties you need—in the right combination for ease of fabrication
- fully annealed tubes for maximum resistance to corrosion
- the benefits of a comprehensive system of quality control that assures uniformity from tube to tube—whether seamless or welded, pressure or mechanical

These are just a few of the many reasons why it pays to specify B&W Job-Matched Stainless Tubing. And remember—matching tubes to jobs assures you the *right tube,* in the *right quantity,* at the *right time.* For more information, call your local B&W District Sales Office, or write for Bulletin TB-365. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

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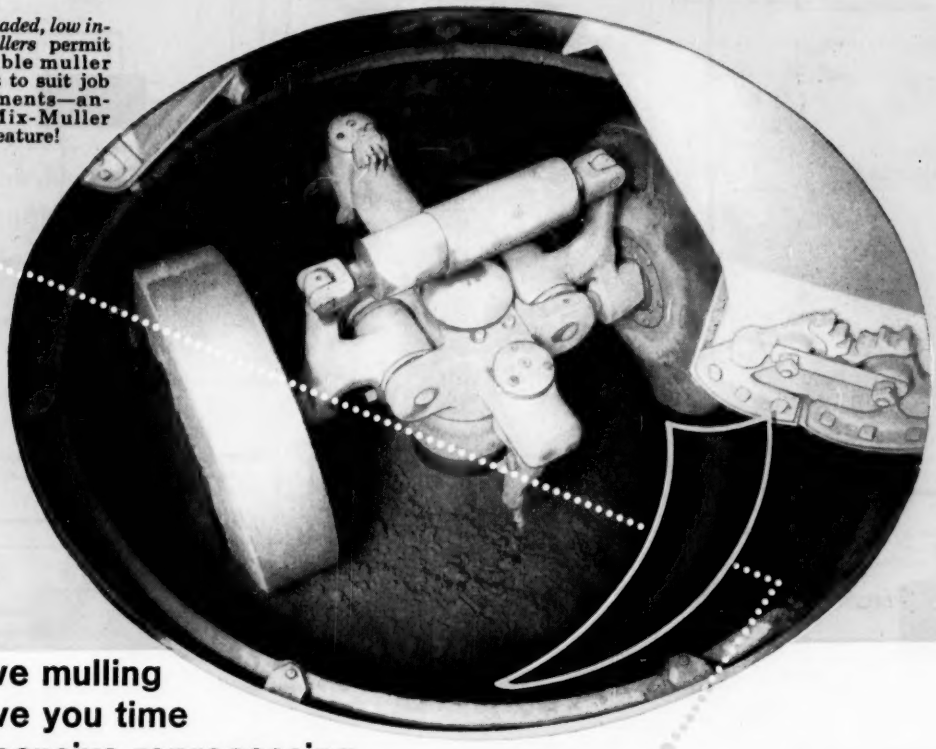
MIX-MULLER®

MEANS CONTROLLED DISPERSION FOR DRY SOLIDS:

Spring loaded, low inertia mullers permit adjustable muller pressures to suit job requirements—another Mix-Muller control feature!



P360

Intensive mulling can save you time and expensive reprocessing

The Simpson Mix-Muller is specifically designed to put *you* in control of mixed properties. In this era of expensive, high purity materials such a machine can, in one operation, help you eliminate reprocessing, remixing and slash waste and rejects simply by making the *most* of prepared ingredients.

For these reasons, the rapid increase in the use of the Simpson Mix-Muller has paralleled the increasing availability of better, more uniform and more *expensive* raw materials.

For similar reasons . . . Mix-Muller usage has paralleled a new, enlightened attitude on mixing practice among processors who have learned that careful attention to mixing operations can be their most important source for *savings*.

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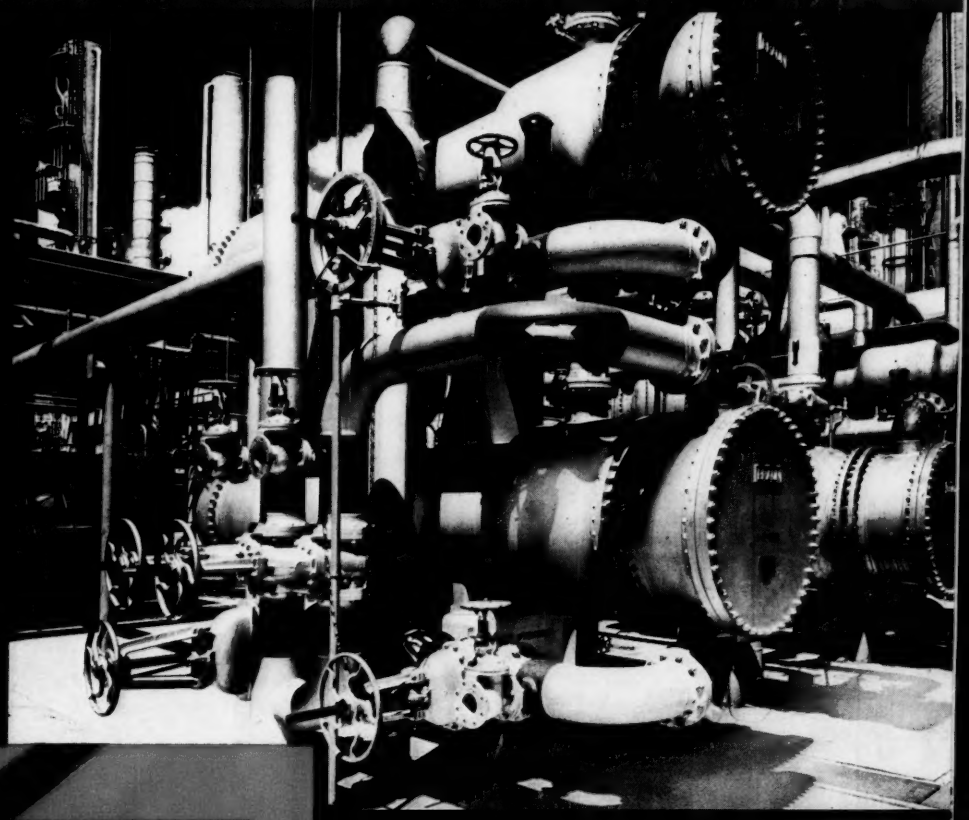

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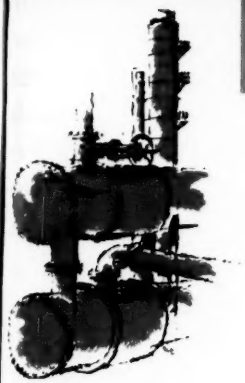

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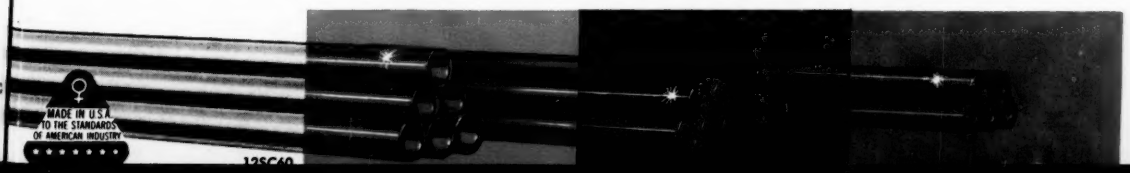

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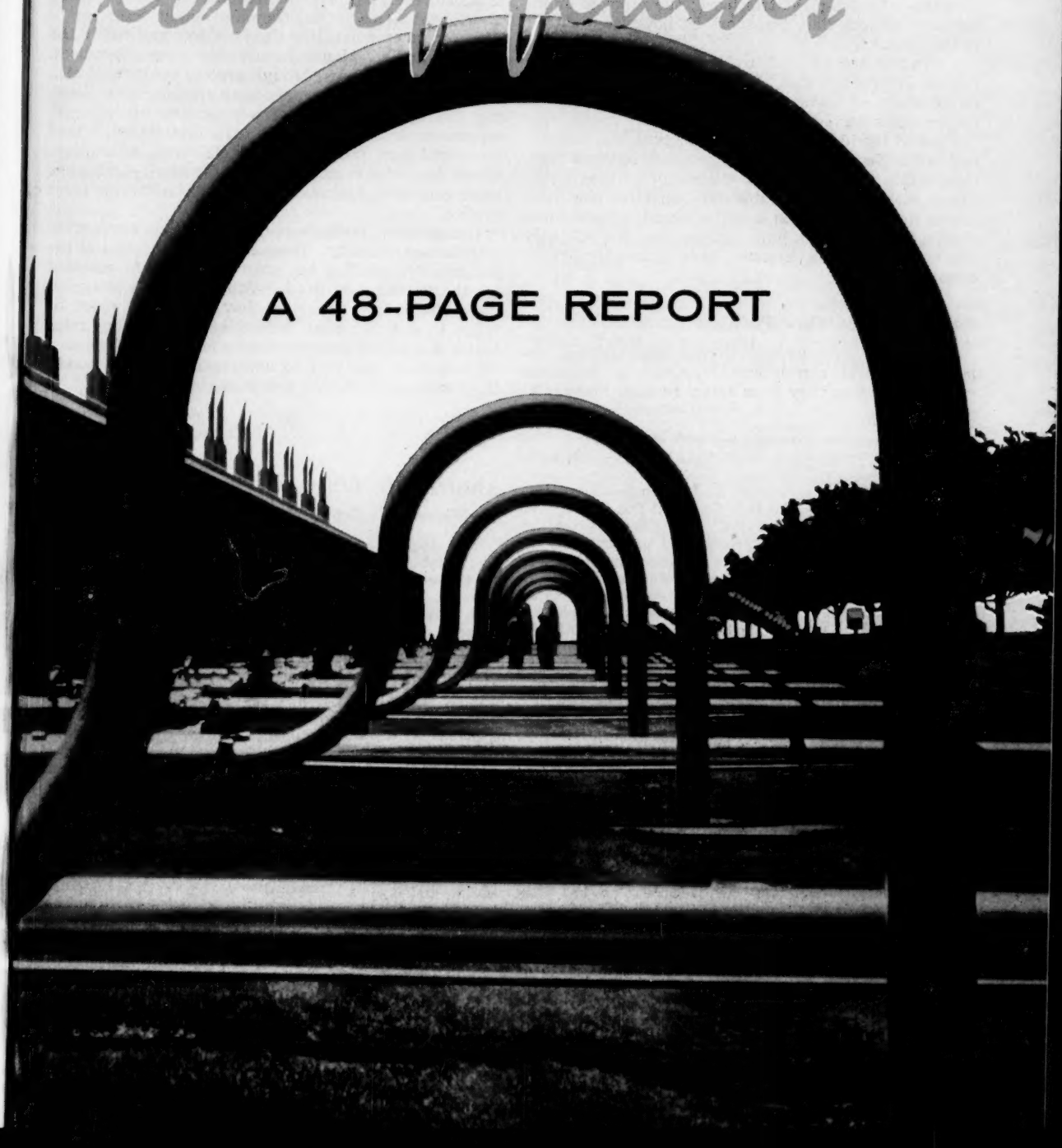
Chemical Engineering
JUNE 13, 1960

FOR PROCESS DESIGN:

flow of fluids



A 48-PAGE REPORT

ERNEST E. LUDWIG
Process Engineering Manager
Dow Chemical Co., Texas Div., Freeport, Tex.

TRANSPORTATION of fluids, both liquid and gas, is economically one of the more important problems for process design. In many chemical process industry "fluid" plants, piping and its accessories may account for nearly half the capital investment. In this report—only a small part of a book on process design to be published by McGraw-Hill next year—we will consider two facets of the fluid flow problem.

• In the first half, we will cover process design for the conduits of flow—more specifically, circular pipe, tubing and fittings. In this section, we will emphasize problems of intra-plant transport; the problem of interplant, or long-line, transport is, however, detailed in the book.

• In the second half, we'll discuss how to pump liquids in process lines. In this section emphasis is on selection of pumps—particularly centrifugals—to meet process performance requirements.

Flow of liquids, gases, vapors, suspensions, slurries and other Newtonian fluid systems has received sufficient study to rationalize a variety of process situations. Although considerable data exist for non-Newtonian fluids, correlation is not so broad; physical and rheological properties limit application. We will only consider Newtonian systems here, unless otherwise noted.

Background of Flow Problem

Because of various simplifying assumptions, the many empirical correlations representing frictional resistance to flow vary from actual results. Some relations agree in one region, diverge in another. We believe correlations included here fit average plant design conditions with good engineering accuracy. For exercise of proper judgment, the designer should know the background of methods presented.

The design problem may be:

1. With flow rate and allowable pressure drop established, determine pipe size for a fixed length, or
2. With flow rate and pipe length known, determine pressure drop and line size.

Usually either problem requires a trial approach based upon assumed pipe sizes to meet the stated conditions. (In some design problems, you may need to find maximum flow for a fixed line size and length; this, however, is just the reverse of the problems above.)

Optimum economic line size is seldom realized in the average process plant. Future flow rate allowances, actual pressure drops through process equipment, etc., can easily over-balance any design predicated on selecting the optimum. But certain guides to order-of-magnitude costs and sizes can be established, either by correlation or by conventional cost estimating. Often the latter is more realistic for given conditions, since generalized equations may not fit a specific plant system.

Unless noted, methods suggested here do not contain any factors of safety. These should be included at the designer's discretion but only to the extent justified by the problem at hand. Although most designers place the safety factor on flow rate, care must be taken to analyze actual conditions at operating rates below this value. In some cases a large factor imposed on flow rate may lead to unacceptable system conditions causing erroneous design decisions.

ERNEST E. LUDWIG has been with the Dow Chemical Co., Texas Div., since 1942. His chief interest has been process and project work for new plant construction and design—both organic and inorganic. He is now process engineering manager, having started with Dow as a chemical process engineer. All Mr. Ludwig's service has been at Dow's Freeport, Texas, plant except for a short period at Houston.

Mr. Ludwig holds a B.S. and M.S. in Chemical Engineering from the University of Texas. He has also taken a special course in operations research at Case Institute as well as extension courses from Texas A&M and from his alma mater.

An active professional engineer, Ludwig is a member of the AIChE, ACS, NSPE and the Texas Society of Professional Engineers. He is a registered P.E., both chemical and mechanical, in the State of Texas. Ludwig is chairman of the equipment area of the National Program Committee, AIChE, and a member of Equipment Testing Procedures, Evaporators Subcommittee. In the past, he has been Secretary, Executive Committee Member and Chairman of Awards, Student Activity and Budget Committees, South Texas Section, AIChE. He organized the Brazosport Subsection of the South Texas Section, AIChE and became its first Chairman.

Mr. Ludwig is married and has two sons. The Ludwigs live in Lake Jackson, Texas.

ABOUT THE BOOK

Or Where This Report Came From

This 48-page *Chemical Engineering* Report is based on two chapters taken from the upcoming McGraw-Hill book by the author. The over-all theme of the book will be, "Process Design for Chemical and Petrochemical Plants."

It will present as orderly a view as possible of the process design engineer, his duties and responsibilities, with a detailed breakdown of his job as it pertains to sizing and rating the specific items of process equipment that make up a process plant.

Since the scheduled publication date of the book is Spring 1961, we thought you would benefit from a preview abstract of these two chapters. Process design for movement of fluids is basic training for every chemical engineer. In this Report, the process engineering manager of a major division of a large chemical company shows you how to combine chemical engineering fundamentals with chemical engineering practice. He shows you how to solve the practical problems of process engineering design.

In addition to chapters on movement of fluids, the book will also cover: process design planning; engineering flowsheets and project schedules; materials of construction; equipment design, rating and specification; mass transfer operations; heat transfer operations; mechanical separations; mixing; venting and safety relief devices; other types of process equipment; safety; and economics in process design. To material that appears in this Report, the book adds many other design problems of fluid flow, including those of compressor and fan systems.

As a general guide, safety factors of 20-30% on the friction factor will account for change in roughness of steel pipe in average service over a 5-10 year period. (Beyond this, conditions often remain static but could deteriorate further.) This still doesn't allow for increased pressure drop due to increased flow rates. Such factors are about 10-20% additional. For many applications, the conservative Cameron Tables[20] give good direct-reading results for long-term service.

Approaching the Problem

Design practice breaks any over-all process problem into smaller parts for simple analysis and solution. This, then, is the recommended approach for selection and sizing of process piping.

Total pressure drop for a particular pipe installation is the sum of friction drop in pipe, valves and fittings, plus drop through control valves, plus drop through equipment in the system, plus static drop due to elevation or pressure level. Although not necessarily required in determination of system frictional losses, this total pressure loss is necessary to establish gravity flow or pumping head requirements for a complete system.

To tackle pipe system problems, it is necessary to keep certain bits and pieces of information and know-how in mind. Among these are the following:

• If gas or vapor density follows perfect gas law,

$$\rho = 144P/(1{,}544T/MW), \text{ lb./cu.ft.} \quad (1)$$

• Gas or vapor specific gravity may be referred to air,

$$S_g = MW \text{ of gas}/MW \text{ of air} = MW \text{ of gas}/29$$

• For conversion between head loss, ft., and pressure drop, psi.,

$$\text{Pressure drop, psi., } \Delta P = h_L\rho/144 \quad (2)$$

$$\text{For water: } \Delta P = h_L/2.31 \quad (3)$$

• Equivalent diameter is used to determine N_{Re} (not velocity) for noncircular ducts or pipes and for circular ducts in which flow is not full. It does not apply to very narrow or slotted flow cross-sections. For equivalent diameter,

$$d_e = 4\left[\frac{\text{duct cross-section available for flow}}{\text{wetted perimeter of duct}}\right]$$

• Minimum size of pipe is sometimes dictated by structural considerations; e.g., 1½ in. Schedule 40 steel pipe is the smallest size to span a 15-20 ft. pipe rack without intermediate support. Too, disregarding smaller calculated size as potential source of trouble, the designer often sets gravity flow lines at 1¼-2 in. minimum.

• Design overflow pump suction lines for about 1 ft./sec. velocity unless higher velocity is necessary to keep small solids or precipitates in suspension. Flooded suction lines to pumps must be designed so that pipe pressure drop is less than available head.

• For mean pressure in a gas line, particularly a long flow line,[24]

$$P_{avg.} = 2/3 \times \left[(P_1 + P_2) - \frac{P_1P_2}{P_1 + P_2}\right] \quad (4)$$

• Usual economic range for pressure loss due to liquid flow is, for suction piping, 0.5-1.25 psi./100 equivalent ft. of pipe; for discharge piping it's 1-5 psi./equivalent ft. of pipe.

Reynolds Number Is Primary

The dimensionless Reynolds number is the basis for establishing condition or type of fluid flow in a pipe. Often used as a parameter for design correlations, the Reynolds number may be expressed in many ways:

$$N_{Re} = Dv\rho/\mu_e = 123.9dv\rho/\mu = 6.31W/d\mu \quad (5)$$

$$N_{Re} = 22{,}700q\rho/d\mu = 50.6Q\rho/d\mu = 0.482q'_wS_e/d\mu \quad (6)$$

Reynolds numbers below 2,000 to 2,100 are usually considered to define laminar or viscous flow, numbers from 2,000 to 3-4,000 a transition region of peculiar flow, and numbers above 4,000 a state of turbulent flow.

Another number associated with rationalization of fluid flow is the friction factor. Two friction factors are commonly found in the literature; the Fanning friction factor is just one-quarter the value of the Darcy friction factor. The latter expression is used throughout this report. For laminar, or viscous, flow the Darcy friction factor is

$$f = 64/N_{Re} \quad (7)$$

For transition and turbulent flow, use Figs. 1 and 2, pp. 164-65.

Such gases as hydrogen, carbon monoxide, carbon dioxide, nitrogen and oxygen are often wet—saturated with water vapor. For flow of these gases in long steel pipes, it may be necessary to increase friction factor by factor of 1.2-2.0 to account for corrosion.

Friction Loss in Fittings

As fluids flow through pipe, elbows, tees, vessel connections, valves and other equipment, friction head losses develop. These losses are expressed as loss of fluid static head in feet of fluid flowing or as equivalent length of straight pipe of the same size that produces same amount of static head loss at the specified flow rate.

If losses are expressed as equivalent pipe diameters, it's a simple matter to convert to equivalent feet of fluid.

$$L_{eq.} = D(L/D)_{eq.} \quad (8)$$

The term $(L/D)_{eq.}$ is often found on charts or in equations.

Head loss has been correlated as a function of the velocity head equation using K coefficients in the equation

$$h_L = Kv^2/2g = Kv^2/64.4 \quad (9)$$

Values for the resistance coefficient K for the usual components of process piping can be found in Ref. 21.

Fig. 3, p. 166, is a popular nomograph[8] for quick selection of equivalent lengths of most fittings and valves. Fig. 4, p. 167, adds welding type pipe fittings as well.[23] After equivalent lengths are determined, they must be added to straight-pipe length before computing total head loss. But head losses calculated using K coefficients from these figures can be added directly to total friction head loss for straight-pipe portions of a system.

Note that comparison of results from these charts does not yield exact checks on any particular fitting.

Calculations should never be represented as being more accurate than the basic information; rounded values, to no more than one decimal place, are limits for such head loss calculations.

Friction loss in rubber-lined pipe is equivalent to that in new steel pipe one-half to one nominal size smaller. For a given inside diameter, friction loss is the same as, or slightly less than, that of clean steel pipe.

In the turbulent flow range, friction loss in glass pipe is 70-85% of that of clean steel.

For 2-in. (nominal) and larger vinyl, Saran or hard rubber pipe, friction loss does not exceed that of clean steel. With 2.5-in.-size Saran- or rubber-lined pipe the loss is about equal to that of clean steel, increasing to 2-4 times the loss at 1-in. size.

Calculate Friction Loss for Water

Based upon the Darcy rational analysis, Table I, p. 168, conveniently summarizes trial velocities for friction loss calculations in standard Schedule 40 pipe. Here's the procedure to determine friction loss for flowing water, starting with this tabulation:

1. Using known flow rate in gal./min. and the suggested velocity from Table I, select an approximate line size from tabulation of $\Delta P/100$ in Ref. 7.

2. Estimate, or count from drawing or tabulation, total linear feet of pipe, L, that is specified for the piping system.

3. Estimate, or use actual tabulation, number of elbows, tees, crosses, globe valves, gate valves and other fittings in system. Convert these to equivalent straight pipe L_e using nomographs of Figs. 3 and 4 or to head loss using resistance coefficient K correlations in Ref. 21.

4. Determine expansion and contraction losses, if any, from Ref. 21 or Figs. 3 and 4. Convert units: Head loss, in ft. $\times$ 0.4331 = psi. (This term can usually be neglected for most liquids at reasonable velocities, less than 10 ft./sec.)

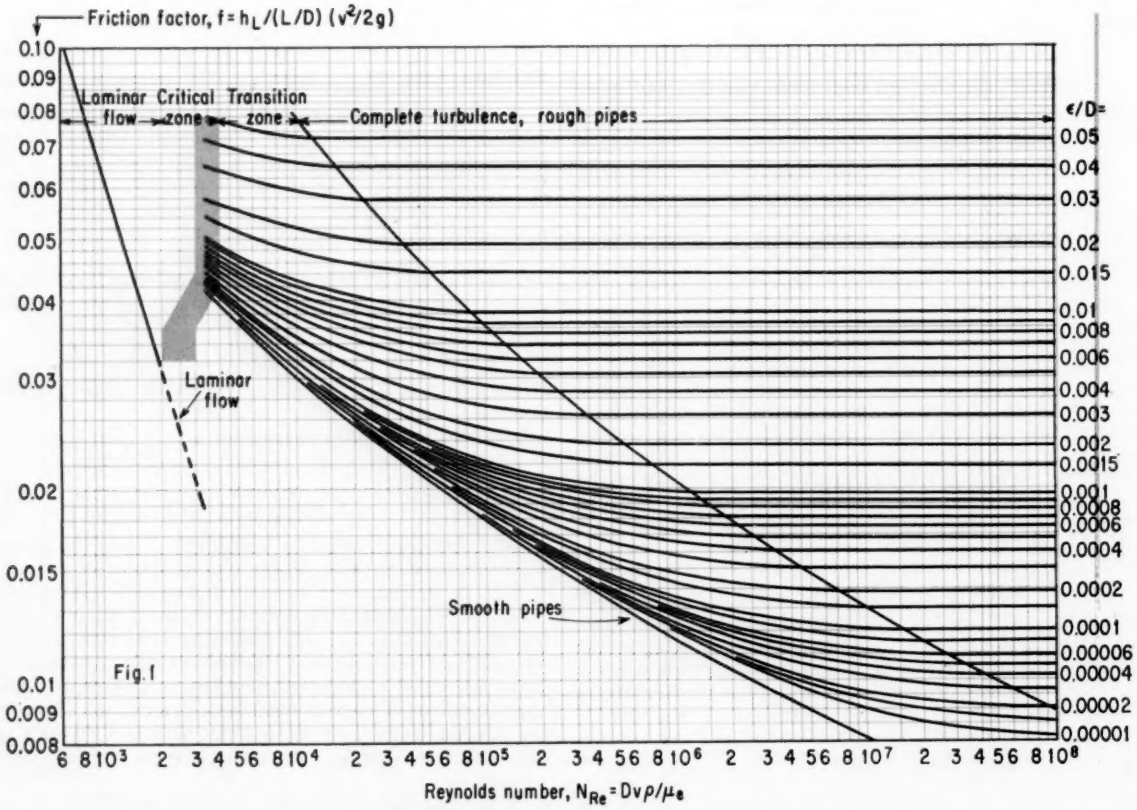
5. Estimate pressure drop through orifices, control valves and other items not covered above.

6. Calculate total pressure drop.

$$\Delta P = (L + \Sigma L_{eq.})(\Delta P/100 \text{ ft.}) + \text{Item 4} + \text{Item 5} \quad (10)$$

The second factor of the first term in this expression can be found for the case of water, for example, tabulated in Ref. 7 and elsewhere. If the pressure drop calculated from Eq. (10) is too large or too small, repeat procedure using larger or smaller pipe as may be indicated.

Tables to determine head loss that appear in Cameron[20] are easy to use, but they give much more con-



FRICTION FACTOR for flow in pipes.

servative results (about twice unit head loss) than the method and references outlined above.

Loss in Water Flow System

Example 1—The system of Fig. 5, p. 168, consists of 125 ft. of Schedule 40 steel pipe on the discharge side of a centrifugal pump. Flow rate is 500 gal./min. at 75 F. Although the tank is located above the pump, this elevation difference doesn't enter pipe size-friction drop calculations. Elevation difference does affect pump selection and so will be considered in the latter section of this Report but not here.

Following is solution based upon the procedure outlined previously:

1. From Table I, select 6 fps. as a reasonable and usual economical water rate.

From tabulated value of $\Delta P/100$ ft., Ref. 7, velocity of water is 5.55 fps. at 500 gal./min. and head loss of 0.720 psi./100 ft. in 6-in. pipe. In 5-in. pipe velocity is 8.02 fps., which is reasonable, but 5-in. pipe is not commonly stocked in many plants; too, the velocity is above usual economical pumping velocities. Use the 6-in. pipe.

2. Linear measure of straight pipe, $L = 125$ ft.

3. Equivalent length of fittings is found from Fig. 3. For a 6-in., 90° ell, $L_{eq.} = 14$ ft. of straight pipe (using medium sweep elbow to represent a welding ell). Note that Fig. 4 gives $L_{eq.} = 6.5$ ft. This shows the difficulty of obtaining close or exact values for design.

Continuing with Fig. 3: for three 90° ells, $L_{eq.} = 3 \times 14 = 42$ ft.; one tee, $L_{eq.} = 12$ ft. (run of standard tee); for one 6-in. open gate valve, $L_{eq.} = 3.5$ ft. Total $L_{eq.}$ is the sum of these, 57.5 ft.

4. Since it's so small, neglect expansion loss at entrance to tank.

5. There are no orifices or control valves in system.

6. From Eq. (10) total pressure drop from face of discharge flange on pump to nozzle connection on tank is

$$\Delta P = (125 + 57.5)(0.720/100)$$
$$= 1.31 \text{ psi.} = 3.02 \text{ ft. water}$$

A somewhat more accurate result can be obtained by using loss coefficients K in Ref. 21. But most engineering design calculations for this type of pressure system do not warrant the extra detail.

Calculate Loss for Other Liquids

The only reason to differentiate between water and other liquids is convenience of separate correlations and tabulations for the oft-used water system. Friction drop calculations for other liquids follow a similar procedure.

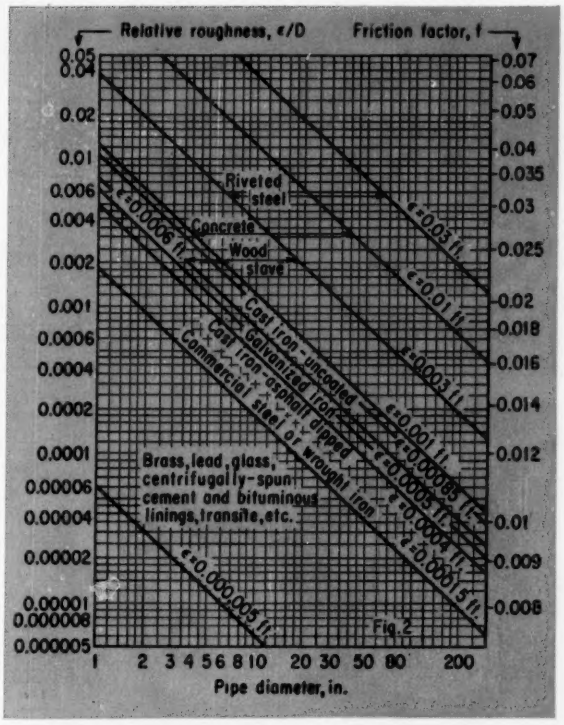
1. Using known flow rate, gal./min., and suggested velocity from Table I, estimate pipe size by the relation for mean velocity of any liquid flowing in a pipe[7]

$$v = 0.408Q/d^2 = 0.0509W/d^2\rho \quad (11)$$

$$d = (0.408Q/v)^{0.5} = (0.0509W/v\rho)^{0.5} \quad (12)$$

2. Estimate or otherwise determine the linear feet of straight pipe in the system, L.

3. Estimate or otherwise determine number of fittings, valves, etc., in system. Convert these to equivalent straight pipe using Fig. 3 or Fig. 4, or to head loss using K coefficients of Ref. 21.



ROUGHNESS FACTORS for new, clean pipe.

4. Determine expansions or contraction losses from Fig. 3 or 4. Convert units to psi.

5. Estimate pressure drop through orifices, control valves and other miscellaneous items in system.

6. Determine pressure drop/unit length as follows: Calculate Reynolds number from Eqs. (5) or (6). At ϵ/d value taken from Fig. 2, read friction factor f from Fig. 1. Calculate pressure drop/100 ft. of pipe.[7]

For turbulent flow, $N_{Re} > 2{,}000$:

$$\Delta P/100 \text{ ft.} = 0.0216f\rho Q^2/d^5 = 0.000336fW^2/(d^5\rho) \quad (13)$$

For laminar, or viscous, flow, $N_{Re} < 2{,}000$:

$$\Delta P/100 = 0.0668\mu v/d^2 = 0.0273\mu Q/d^4 = 0.0034\mu W/(d^4\rho) \quad (14)$$

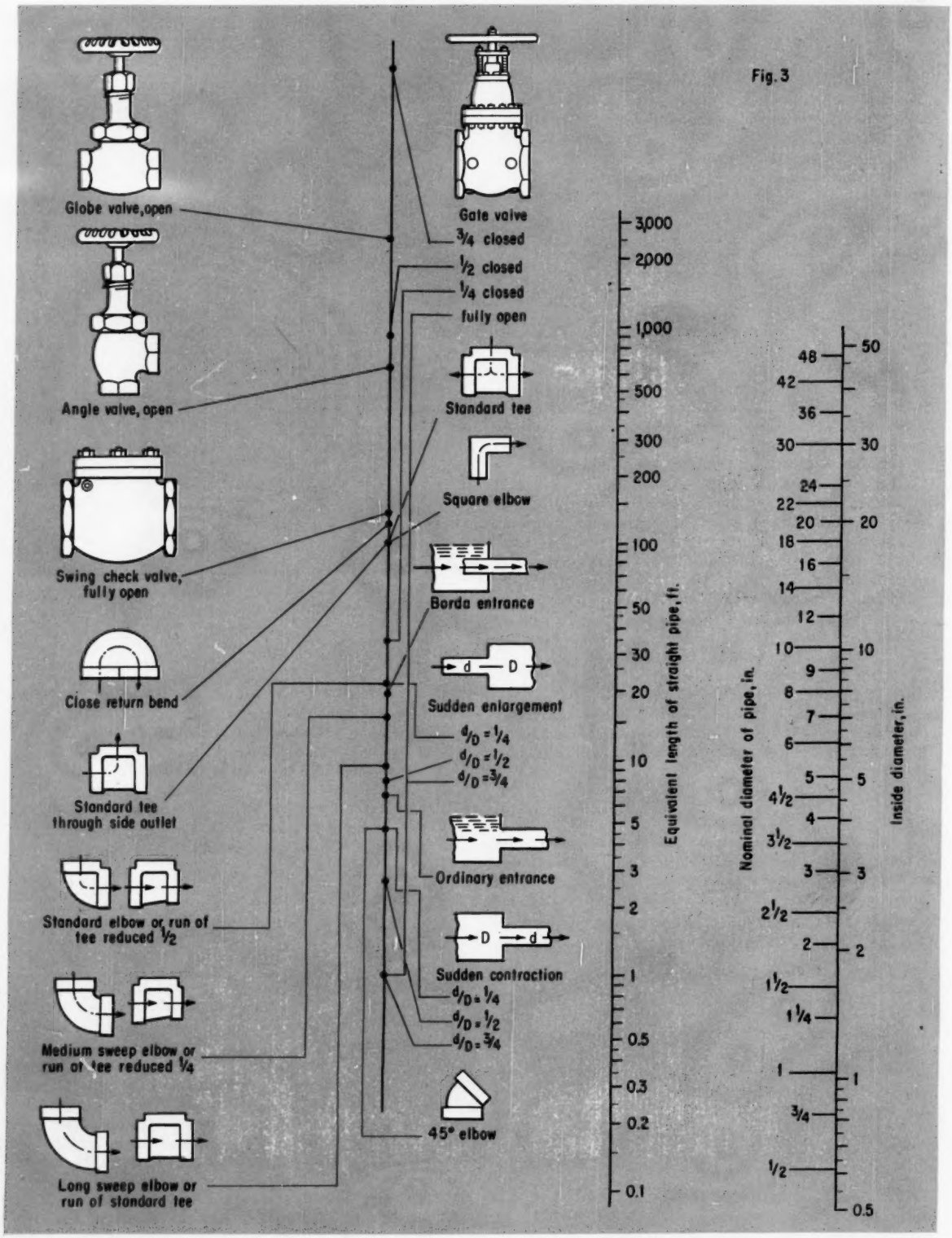
7. Calculate total pressure drop for system.

$$\Delta P = (L + \Sigma L_{eq.})(\Delta P/100 \text{ ft.}) + \text{Item 4} + \text{Item 5}$$

Second factor of first term is calculated from step 6 in procedure. If pressure drop is too large or small, recalculate by adjusting pipe size in indicated direction. Cameron tables[20] for miscellaneous liquids give conservative figures. Fig. 13, p. 176, of this Report gives friction drop directly for Dowtherm liquid.

Example 2—Pipe flow system with liquid of specific gravity other than water's. System and calculation are shown on the line size sheet, Fig. 6, typical of those used in process design.

Fig. 8, p. 170, represents a liquid reactor system discharging crude product similar to glycol through a flow control valve and orifice into a storage tank. Reactor is at 350 psig., 280 F.; liquid specific gravity is



FLOW RESISTANCE of valves and fittings.

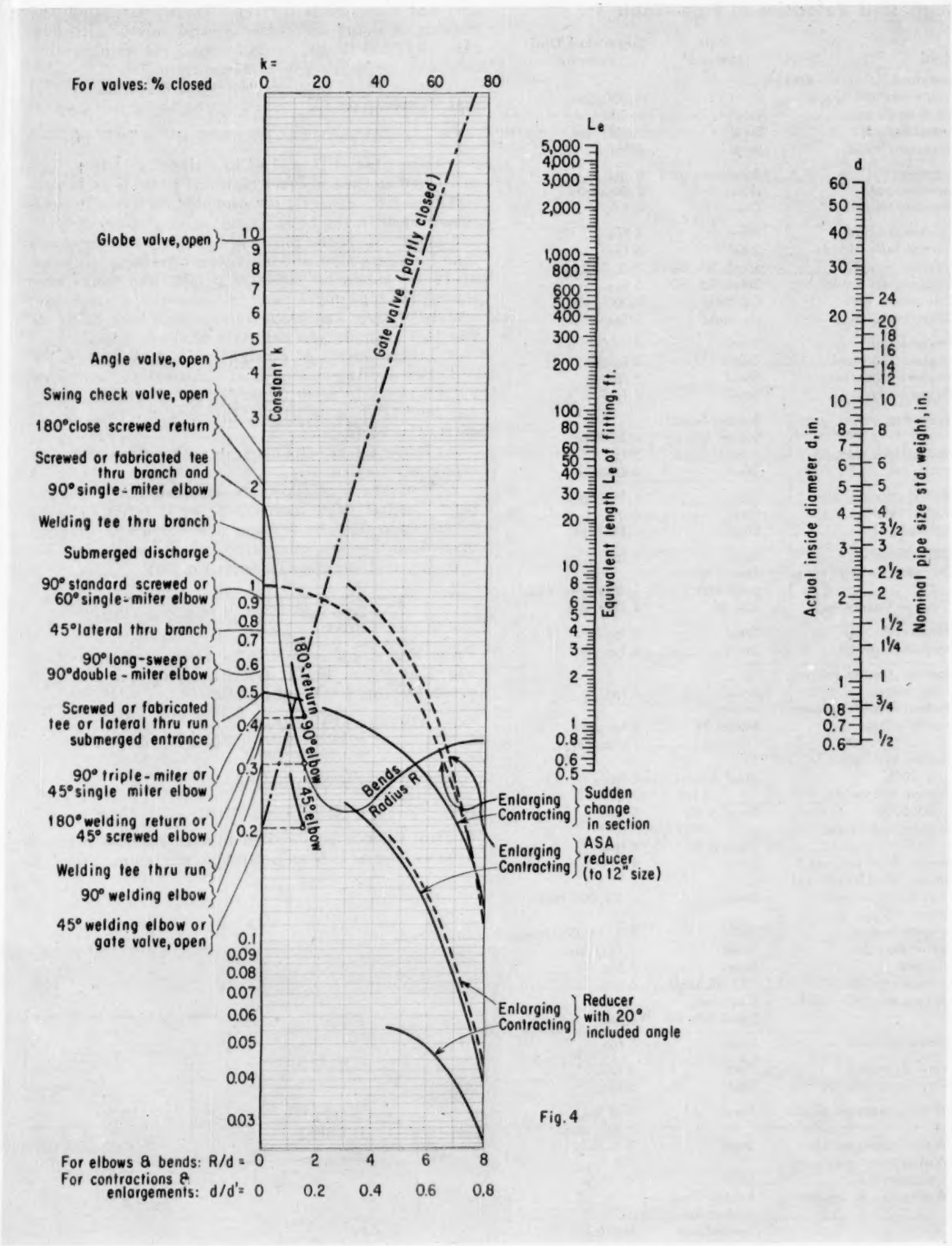


Fig. 4

EQUIVALENT LENGTH of fittings for turbulent flow.

Suggested Velocities in Pipe—Table I

Fluid	Pipe Material	Suggested Trial Velocity
Acetylene (observe pressure limitations)	Steel	4,000 fpm.
Air, 0 to 30 psig.	Steel	4,000 fpm.
Ammonia, gas	Steel	6,000 fpm.
Ammonia, liquid	Steel	6 fps.
Benzene	Steel	6 fps.
Bromine, gas	Glass	2,000 fpm.
Bromine, liquid	Glass	4 fps.
Calcium chloride	Steel	4 fps.
Carbon tetrachloride	Steel	6 fps.
Chlorine, dry gas	Steel, Sch. 80	2–5,000 fpm.
Chlorine, dry liquid	Steel, Sch. 80	5 fps.
Chloroform, gas	Cu, steel	2,000 fpm.
Chloroform, liquid	Cu, steel	6 fps.
Ethylene, gas	Steel	6,000 fpm.
Ethylene dibromide	Glass	4 fps.
Ethylene dichloride	Steel	6 fps.
Ethylene glycol	Steel	6 fps.
Hydrochloric acid, gas	Rubber-lined, Saran, Haveg	4,000 fpm.
Hydrochloric acid, liq.	Rubber-lined	5 fps.
Hydrogen	Steel	4,000 fpm.
Methyl chloride, gas	Steel	4,000 fpm.
Methyl chloride, liq.	Steel	6 fps.
Natural gas	Steel	6,000 fps.
Oils, lubricating	Steel	6 fps.
Oxygen (ambient temp.)	Steel (300 psig. max.)	1,800 fpm. max.
Oxygen (low temp.)	304 SS	4,000 fpm.
Perchlorethylene	Steel	6 fps.
Propylene glycol	Steel	5 fps.
Sodium chloride solution, no solids	Steel	5 fps.
Sodium chloride solution, with solids	Monel, Ni	6 fps., min. 15 fps., max.
Sodium hydroxide, 0–30%	Steel & Ni	6 fps.
Sodium hydroxide, 30–50%	Steel & Ni	5 fps.
Sodium hydroxide, 50–73%	Steel & Ni	4 fps.
Steam, 0–30 psi., sat.*	Steel	4–6,000 fpm.
Steam, 30–150 psi., sat. or superheated*	Steel	6–10,000 fpm.
Steam, 15 psi. up, superheated	Steel	6½–15,000 fpm.
Sulfur dioxide	Steel	4,000 fpm.
Styrene	Steel	6 fps.
Sulfuric acid, 88–93%	316 SS, lead	4 fps.
Sulfuric acid, 93–100%	Cast iron, Steel, Sch. 80	4 fps.
Trichlorethylene	Steel	6 fps.
Vinyl chloride	Steel	6 fps.
Vinylidene chloride	Steel	6 fps.
Water, average service	Steel	3–8 fps., 6 fps., avg.
Water, pump suction	Steel	3–8 fps.
Water, usual maximum economical	Steel	5–8 fps. 7–10 fps.
Water, sea & brackish	Rubber-lined, asphalt-lined, Saran-lined concrete-lined	5–8 fps. 5–12 fps.

* Short lines, 15,000 fpm. max.

0.93 and viscosity is 0.91 cp. There's essentially no flashing of liquid across the control valve. With flow rate of 11,000 lb./hr. or 23.7 actual gal./min., design rate is set at $23.7 \times 1.05 = 25$ gal./min.

1. From Table I, select velocity of 6 fps. Estimated pipe diameter is

$$d = (0.408Q/v)^{0.5} = [(0.408)25/6]^{0.5} = 1.3 \text{ in.}$$

Try 1½-in. pipe (I.D. = 1.61 in.) since 1¼ (I.D. = 1.38 in.) is not stocked in every plant. If 1¼ in. is an acceptable pipe size, check it; it's probably no worse in pressure drop than the 1½-in. pipe.

Support of 1¼-in. pipe may require shorter spans than for 1½-in. pipe, and most plants prefer a minimum of 1½ in. valves on pressure vessels and tanks even though the pipe might be 1¼ in. However, control valve system of gate and globe valves could well be 1¼ in. For this example, use Schedule 40, 1½-in. pipe.

2. Linear length of straight pipe, $L = 254$ ft.

3. For equivalent length of accessories: Ten-1½ in., 90° elbows, $L_{eq.} = 40$ ft.; eight-1½ in. tees, $L_{eq.} = 24$ ft.; four-1½ in. gate valves, $L_{eq.} = 4$ ft. Total $L_{eq.} = 68$ ft. Use 75 ft.

4. There are no expansion or contraction losses except control valve.

5. Pressure drop allowance assumed for orifice is 5 psig. Control valve loss will be by difference, trying to maintain 60% of friction plus valve loss as minimum drop through valve.

6. Reynolds number is, from Eq. (6),

$$N_{Re} = 50.6\,Q\rho/d\mu$$
$$= [50.6 \times 25 \times 0.93 \times 62.3]/(1.61)\,(0.91)$$
$$= 46{,}600$$

From Fig. 2, $\epsilon/d = 0.0012$ for 1½-in. steel pipe; from Fig. 1 at $N_{Re} = 46{,}600$, friction factor $f = 0.021$. So pressure drop/100 ft. of pipe is

$$\Delta P/100 = 0.0216\,f\rho Q^2/d^5$$
$$= 0.0216\,(0.021)\,(62.3)\,(0.93)\,(25)^2/(1.61)^5$$
$$= 1.52 \text{ psi./100 ft.}$$

7. For total pressure drop,

$$\Delta P = (254 + 75)\,(1.52/100) + 5 = 10 \text{ psi.}$$

Control valve must be sized to take residual pressure drop as long as it is an acceptable minimum. Since the

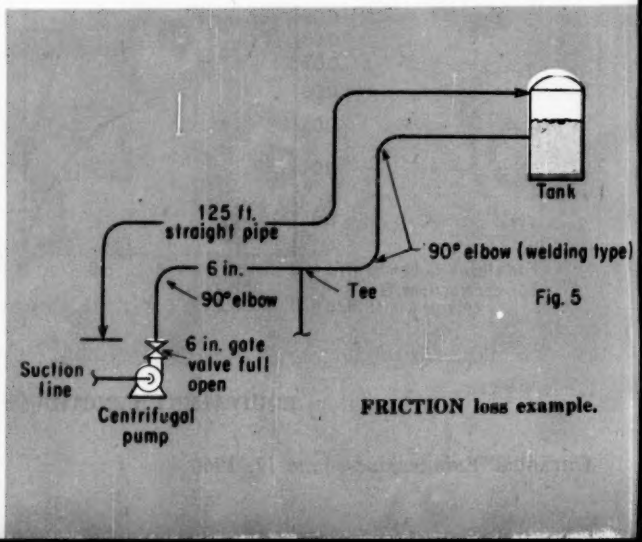


Fig. 5 FRICTION loss example.

By ABC

LINE SIZE SHEET

Job No. _____

Date 6-3-59

Charge No. _____

Line No. LP - 51

Flow Sheet Drawing No. _____

Line Description Reactor Discharge

Fluid in line Crude Product

Temperature 280 °F

GPM (Calc.) 23.7 GPM (des.) 25 Pressure 350 psig

CFM (Calc.) _____ CFM (des.) _____ Sp. Gr. 0.93

Lbs./hr.(Calc.) _____ Lbs./hr.(des.) _____ Sp. Vol. _____ cu.ft./lb.

Recommended Velocity 6 fp S Viscosity 0.91 cp

Straight pipe, fittings, valves expansion, contraction, etc.

Item	No.	Unit Eq. Ft.	Total Eq. Ft.	
Pipe	254	1	254	
90°Elbow	10	4	40	*
Tee	8	3	24	*
Gate Valve	4	1	4	*
		Total	329	

* Rounded total to 75 sq.ft.
** By Difference

Item	Pressure Drop in-	
Pipe & Equivalent	5)	
Orifice	5) = 10	
Motor Valve	340	**
Miscellaneous		
Total	350	

Estimated line size 1½"

Actual Velocity 3.9 fps

Unit Loss per 100 ft. 1.52 psi

Total head loss in feet of liquid 8.45

Total pressure drop in psi 350

Selected pipe size 1½" Material & Weight Sch. 40 Steel

Calculations: $Re = 50.6\,Q\rho/d\mu = 50.6(25)[0.93(62.3)]/(1.61)(0.91) = 46{,}600$

$\epsilon/d = 0.0012$, $f = 0.021$ (Figures -1 and -2)

$\Delta P/100' = 0.0216\, f\rho Q^2/d^5 = 0.0216(0.021)(62.3)(0.93)(25)^2/(1.65)^5$

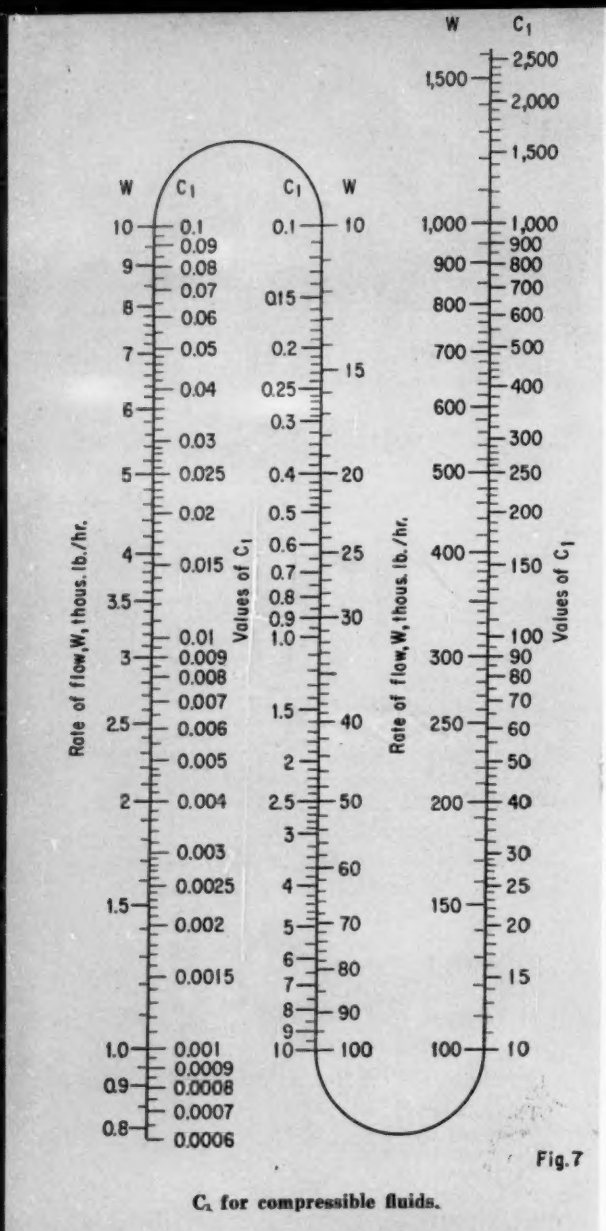
$= 1.52$ psi/100 ft.

Total $\Delta P = (329)(1.52/100) + 5 = 10$ psi

Total loss, feet liquid = 340 (2.31 ft./psi)(1/0.93) = 845 feet

Checked by: _____ Date: _____

PROCESS DESIGNER'S line size sheet—Fig. 6.



C_1 for compressible fluids.

350 − 0 = 350 psi., and total ΔP other than control valve is 10 psi., control valve must take 340 psi. drop.

Note that control valve loss exceeds 60% of total system loss since valve must take the difference. Where this is not the case, system loss must be adjusted to assign about 5-10 psi. or 25-60% of valve-plus-friction loss to the control valve. At a sacrifice of sensitive control, this minimum value of control valve drop can be lowered for very low pressure systems.

Friction Drop for Compressible Fluids

Flow of compressible fluids such as gas, vapor and steam is treated, in general, the same as that of liquids or noncompressible fluids. Specific semi-empirical formulas have been developed to fit particular systems and are acceptable within engineering accuracy.

The Darcy rational relation for steam flow is[7]

$$\Delta P/100 = 0.000336 f W^2 \overline{V}/d^5 \quad (15)$$

$$\Delta P/100 = 0.000001959 f (q_h')^2 S_g^2/(d^5 \rho) \quad (16)$$

General procedures outlined previously for handling fluids with the friction factor-Reynolds number chart, Fig. 1, are used with Eqs. (15) and (16). These apply to compressible flow systems with following qualifications, or break line into sections, calculating new ρ and ΔP for each.

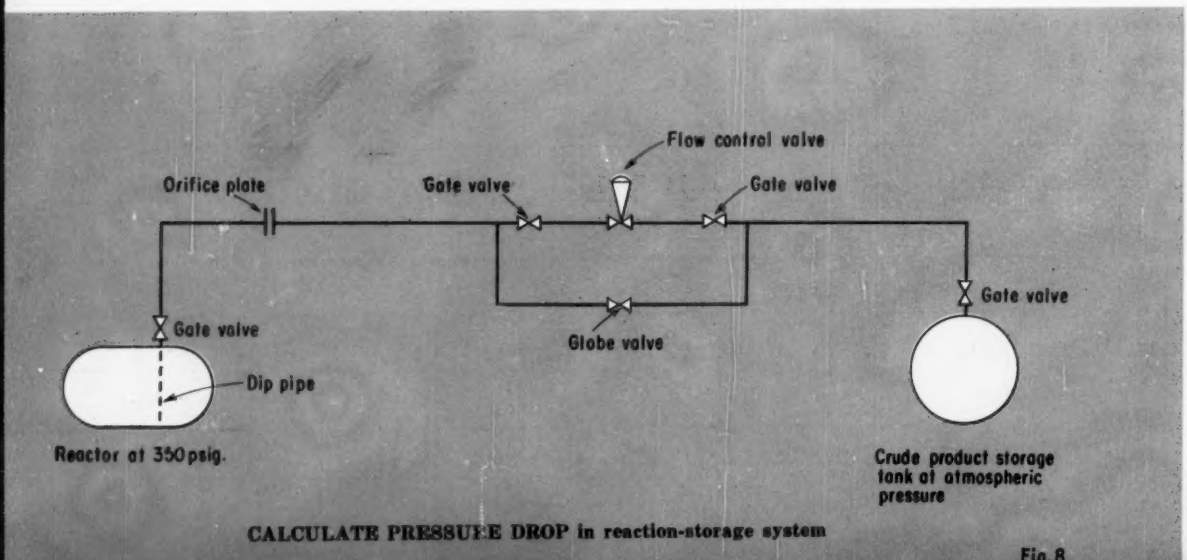
- When total $\Delta P < 10\%$ inlet pressure use ρ or $\overline{V}$ based on inlet or outlet conditions.
- When total $\Delta P > 10\%$ inlet pressure but $< 40\%$, use average ρ or $\overline{V}$ based on inlet and outlet conditions, or break line into sections, calculating new ρ and ΔP for each.
- When total $\Delta P > 40\%$ inlet pressure, use Babcock formula (see p. 172).

Fig. 7 is useful in solving the usual steam flow problem, based on the modified Darcy relation with fixed friction factors. At low velocity, results may be low.

Calculate Drop for Steam Flow

Calculation procedure is as follows:

1. Determine C_1 and C_2 from Fig. 7 and Table II for



CALCULATE PRESSURE DROP in reaction-storage system

Fig. 8

steam flow rate and assumed pipe size. Use Table I to select steam velocity for line size estimate.

2. Read specific volume of steam at given conditions from steam tables, such as Keenan & Keyes, "Thermodynamic Properties of Steam," Wiley, New York (1936).

3. Calculate pressure drop/100 ft. of pipe from

$$\Delta P/100 = C_1 C_2 \overline{V} \qquad (17)$$

4. From Fig. 3 or Fig. 4 determine equivalent lengths of fittings, valves and other accessories.

5. Determine expansion and contraction losses.

6. Determine pressure drops through orifices and control valves.

7. For total system pressure drop,

$$\Delta P = (L + \Sigma L_{(e)})\ (\Delta P/100) + \text{Item 4} + \text{Item 5} + \text{Item 6}$$

If pressure drop is too large, re-estimate line size and

Values of C_2 for Compressible Fluids–Table II

Nominal Pipe Size, In.	Schedule Number*	Value of C_2
⅛	40 s	7.92×10^{5}
	80 x	26.20
¼	40 s	1.59
	80 x	4.29
⅜	40 s	3.19×10^{5}
	80 x	7.18
½	40 s	0.935
	80 x	1.861
	160	43.00
	xx	111.80
¾	40 s	0.212
	80 x	0.369
	160	1.001
	xx	6.27
1	40 s	0.595×10^{4}
	80 x	0.964
	160	2.25
	xx	11.41
1¼	40 s	1.408×10^{3}
	80 x	2.110
	160	3.490
	xx	13.640
1½	40 s	0.627
	80 x	0.904
	160	1.656
	xx	4.63
2	40 s	0.169
	80 x	0.236
	160	0.488
	xx	0.899
2½	40 s	0.667×10^{3}
	80 x	0.918
	160	1.463
	xx	3.80
3	40 s	2.14×10
	80 x	2.87
	160	4.83
	xx	9.66
3½	40 s	1.00
	80 x	3.77
4	40 s	5.17×10^{0}
	80 x	6.75
5	40 s	1.59
	80 x	2.04
	120	2.69
	160	3.59
	xx	4.93
6	40 s	0.610
	80 x	0.798
	120	1.015
	160	1.376
	xx	1.861
8	20	0.133
	30	0.135
	40 s	0.146
	60	0.163
	80 x	0.185
	100	0.211
	120	0.252
	140	0.289
	xx	0.317
	160	0.333
10	20	0.397×10^{-1}
	30	0.421
	40 s	0.447
	60 x	0.514
	80	0.569
	100	0.661
	120	0.753
	140	0.905
	160	1.052
12	20	1.57×10^{-2}
	30	1.68
	s	1.75
	40	1.80
	x	1.95
	60	2.06
	80	2.31
	100	2.67
	120	3.10
	140	3.50
	160	4.23
14	10	0.949
	20	0.996
	30 s	1.046
	40	1.099
	x	1.155
	60	1.244
	80	1.416
	100	1.657
	120	1.898
	140	2.18
	160	2.52
16	10	0.463
	20	0.421
	30 s	0.504
	40 x	0.549
	60	0.612
	80	0.700
	100	0.804
	120	0.926
	140	1.099
	160	1.244
18	10	2.47×10^{-3}
	20	2.56
	s	2.66
	30	2.76
	x	2.87
	40	2.98
	60	3.35
	80	3.76
	100	4.35
	120	5.04
	140	5.73
	160	6.69
20	10	1.41
	20 s	1.50
	30 x	1.61
	40	1.69
	60	1.91
	80	2.17
	100	2.51
	120	2.87
	140	3.35
	160	3.85
24	10	5.34×10^{-4}
	20 s	5.65
	x	5.97
	30	6.14
	40	6.51
	60	7.41
	80	8.35
	100	9.72
	120	11.19
	140	12.74
	160	14.78

* Letters s, x and xx indicate standard, extra strong and double extra strong pipe respectively.

repeat calculations; also examine pressure drop assumptions for orifices and control valves.

Babcock Formula for Steam Flow

Comparison of results between various empirical steam flow formulas suggests the Babcock equation as a good average for most design purposes at pressures 500 psia. and below. For lines smaller than 4 in., this relation may be 0-40% high.[23]

$$\Delta P = p_1 - p_2 = 0.000131\,[1 + (3.6/d)]\,w^2L/(\rho d^5) \quad (18)$$

$$\Delta P/100 = w^2F/\rho \quad (19)$$

Values for F are found in Table III.

Transmission lines over 200 ft. in length should be calculated in sections in order to re-establish steam specific density. To obtain good results, an estimated average ρ should be selected for each line increment.

Example 3—Using Babcock formula for steam flow. Determine the pressure loss in 138 ft. of 8-in. Schedule 40 steel pipe in which 86,000 lb./hr. of 150-psig. saturated steam are flowing.

Using value of $F = 587.1 \times 10^{-9}$ from Table III,

$$\Delta P/100 = (1{,}432)^2\,(587.1 \times 10^{-9})/0.364 = 3.32 \text{ psi./100 ft.}$$

And for total pressure drop,

$$\Delta P = (3.32/100)\,(138) = 4.57 \text{ psi.}$$

Friction Drop in Long Pipelines

The Panhandle formula[7] presents a relationship for gas flow and friction drop in long pipelines considered slightly better than ±10% accuracy.

$$q_{da} = 435.87\,E\,(T_a/P_a)^{1.07881}\,[(P_1^2 - P_2^2)/S_g^{0.8539}\,TL_mZ]^{0.5394}\,d^{2.6182}$$

or

$$P_1^2 - P_2^2 = [qS_g^{0.4606}/435.87\,E\,(T_a/P_a)^{1.07881}\,d^{2.6182}]^{1.8539}\,TL_m$$

where T is gas flowing temperature, deg. Rankine and E is efficiency factor for flow (1.0 for new pipe without bends, elbows, valves and change of pipe diameter or elevation; 0.95 for very good operating conditions; 0.92 for average operating conditions; 0.85 for poor operating conditions).

For bends in pipe, add to length[5]

Bend Diameter	Add (as pipe diameters, d_o)
1.0	17.5
1.5	10.4
2.0	9.0
3.0	8.2

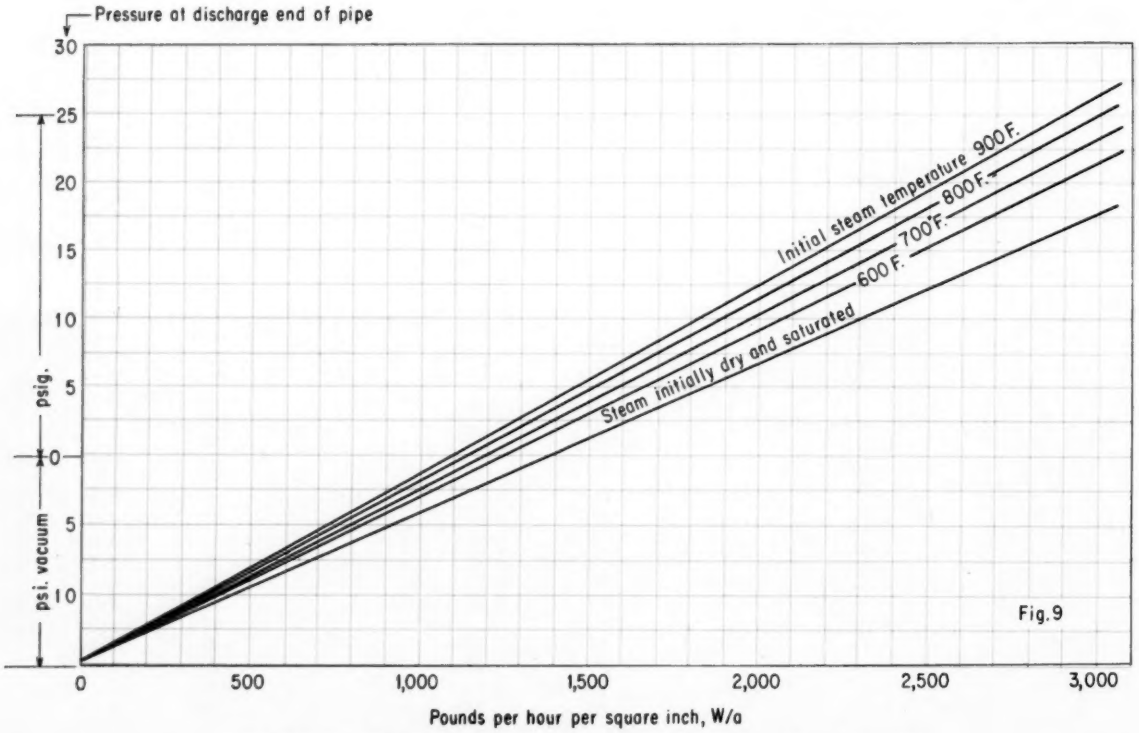
Pipe diameters d_r, of course, must be converted to unit of length used in the formula.

If a line is made up of several different sizes, these sizes can be resolved to one and then the equation solved once for total equivalent length. Handled on a "per size basis and totaled on basis of longest length of one size of line, the equivalent length L_e for any size d, referenced to a basic diameter d_r is

$$L_e = L_m\,(d_r/d)^{4.854}$$

where L_m is length of pipe of size d to be used.

Calculations can be based on diameter d_r and a length of all the various L_e values in the line plus the length of line of size d_r to give a total equivalent length for the line system. After conversion to basis of d_r, L_e is equivalent length of pipe size d and L_m.



DISCHARGE PRESSURE in steam pipe operating at maximum capacity.

Weymouth Formula for Long-Line Flow

Tests of the U. S. Department of Interior, Bureau of Mines, reported in Ref. 10, indicate that the Weymouth Formula gives good results on flow measurements on lines of 6-in. dia. and larger when operating under steady flow conditions of 30-600 psig. Dunning[5] recommends this formula for lines 4- to 24-in. dia., specific gravity of gas near 0.6 and actual mean velocities from 15-30 ft./sec. at 60 F.

The Bureau of Mines report states that minor corrections for bends, tees and even compressibility are unnecessary because of greater uncertainties in actual line conditions. Their checks, using the Weymouth relation, omitted such corrections. The relation (at pressure base of 14.4 psia.) is used with multipliers found in the Bureau of Mines publication.[10]

$$q_h = 36.926\, d^{2.667}\, [(P_1^2 - P_2^2)/L_m]^{0.5}$$

$$q_h' = 28.0\, d^{2.667}\, [(P_1^2 - P_2^2)\ (520)/S_g\, L_m\, T]^{0.5}$$

The Weymouth Formula is also expressed, at standard conditions,

$$q_d = 433.49\, E\, (T_s/P_s)\, (P_1^2 - P_2^2)/S_g\, TL_m\, Z^{0.5}\, d^{2.667}$$

where E is usually taken as 1.1.

Complex Pipeline Systems

A method is suggested in the Bureau of Mines monograph[10] to handle flow of natural or similar gases in complex—series, parallel, looped, etc.—pipe systems. Using the Weymouth Formula as point of departure, equivalent lengths and diameters can be calculated for these systems.

For equivalent lengths of pipe of different diameters

$$L_1 = L_2\, (d_1/d_2)^{16/3}$$

where L_1 is equivalent length of any pipe of length L_2 and diameter d_2, in terms of diameter d_1.

$$d_1 = d_2\, (L_1/L_2)^{3/16}$$

where d_1 is equivalent diameter of any pipe of given diameter d_2 and length L_2, in terms of any other length L_1.

For equivalent diameters of pipe for parallel lines

$$d_o = (d_1^{8/3} + d_2^{8/3} + \ldots + d_n^{8/3})^{3/8}$$

where d_o is the diameter of a single line with the same delivery capacity as that of the individual parallel lines of diameters d_1, d_2, . . . d_n. This value of d_o can be used directly in the Weymouth Formula.

Example—Series System. Determine the equivalent length of a series of lines: 5 mi. of 14-in. (13¼-in. I.D.) connected to 3 mi. of 10-in. (10.136-in. I.D.) connected to 12 mi. of 8-in. (7.981-in. I.D.)

Select 10 in. as the base reference diameter size. The 5-mi. section of 14-in. pipe is equivalent to

$$L_1 = 5\ (10.136/13.25)^{5.33} = 1.195 \text{ mi. of 10 in.}$$

The 12-mi. section of 8-in. pipe is equivalent to

$$L_1 = 12\ (10.136/7.981)^{5.33} = 42.8 \text{ mi. of 10 in.}$$

Total equivalent length of line to use in calculations is the sum of these, 46.995 mi. of 10-in. pipe. Alternate procedures would be to calculate, in series, (1) pressure drop, one section at a time, or (2) capacity for a fixed inlet pressure.

Example—Looped System. Determine the equivalent length of 25 mi. of 10-in. (10.136-in. I.D.) that has a parallel loop of 6 mi. of 8-in. (7.981-in. I.D.) pipe tied in near midsection of 10-in. line.

Figure the looped section as parallel lines with 6 mi. of 8-in. and 6 mi. of 10-in. pipe. The equivalent diameter for one line with the same carrying capacity as the system is

$$d_o = [(7.981)^{8/3} + (10.136)^{8/3}]^{3/8} = 11.9 \text{ in.}$$

This simplifies the system to one section, 6 mi. long, of 11.9-in. I.D. (equivalent) pipe, plus one section, 19 mi. long, of 10-in. (10.136-in. I.D.) pipe.

Now convert the 11.9-in. equivalent pipe to a length equivalent to 10-in. diameter.

$$L_1 = 6\ (10.136/11.9)^{5.33} = 2.58 \text{ mi.}$$

Total length of 10-in. pipe to use in calculating capacity is 19 + 2.58 = 21.58 mi.

By the principles outlined in the examples, gas pipeline systems can be analyzed for analogous combinations—parallel, cross-tie, etc.

Example—Parallel System; Fraction Parallel. Determine the portion of a 30-mi., 18-in. (17.124-in. I.D.) line that must be paralleled with 20-in. (19.0-in. I.D.) pipe to raise total system capacity 1.5 times existing rate, keeping the system inlet and outlet conditions the same.

$$x = [(q_{da}/q_{db})^2 - 1]/\left\{(1/[1 + (d_b/d_a)^{2.667}]^2) - 1\right\}$$

For this example, $q_{db} = 1.5q_{da}$ so when the values are put in the relationship above, x is 0.683. This means that 68.3% of the 30 mi. must be paralleled with the new 19-in. I.D. pipe.

Problem of Sonic Flow

Sonic, or critical, velocity (speed of sound in the fluid) is the maximum velocity which a compressible fluid can attain in a pipe.[7]

$$v_s = [(c_p/c_v)\ (32.2)\ (1{,}544/MW)\ (460 + t)]^{0.5}$$
$$= 68.1\ [(c_p/c_v)\ P/\rho]^{0.5} \qquad (20$$

where properties are evaluated for condition of sonic

Factor F for Babcock Steam Formula—Table III

Nominal Pipe Size, In.	Standard Wt., Sch. 40 Pipe	Extra Strong, Sch. 80 Pipe
½ I.D.	955.1×10^{-3}	2.051
¾	184.7	340.8×10^{-3}
1	45.7	77.71
1¼	9.432	14.67
1½	3.914	5.865
2	951.9×10^{-6}	1.365
2½	351.0	493.8×10^{-6}
3	104.7	143.2
3½	46.94	62.95
4	23.46	31.01
5	6.854	8.866
6	2.544	3.354
8	587.1×10^{-9}	748.2×10^{-9}
10	176.3	225.3
12	70.32	90.52
14 O.D.	42.84	55.29
16	21.39	27.28
18	11.61	14.69
20	6.621	8.469
24	2.561	3.278

flow. Eq. (20) applies, regardless of downstream pressure, for a fixed upstream pressure. Since it's not built in the pressure drop relations, this limitation must be evaluated separately from them.

If pressure drop is large enough to establish the required velocity, sonic velocity occurs at a restricted point in the pipe or at the outlet. Once sonic velocity has been reached, pressure drop in the system does not increase. Velocity remains at this limiting value even though fluid discharges into a vessel at lower pressure than that at the point where sonic velocity is established.

In general, sonic velocity is attained when there is an outlet or downstream pressure equal to, or less than, one-half the upstream or inlet absolute pressure of a system. Discharge through an orifice or nozzle is usually a limiting condition for flow through the end of a pipe.

The usual pressure drop equations do not hold at the sonic velocity, just as they don't hold in an orifice. Systems exhausting to atmosphere (or vacuum) at medium to high pressures should be examined for critical flow—otherwise the calculated pressure drop may be in error.

Fig. 9 is convenient for calculating steam, exhaust and other systems. Using the chart for given line size, flow rate and steam temperature, limiting pressure at the end of the line can be determined using the usual flow equations but disregarding any lower pressure set by other conditions.

REYNOLDS NUMBERS and friction factors in pipelines for compressible fluids.

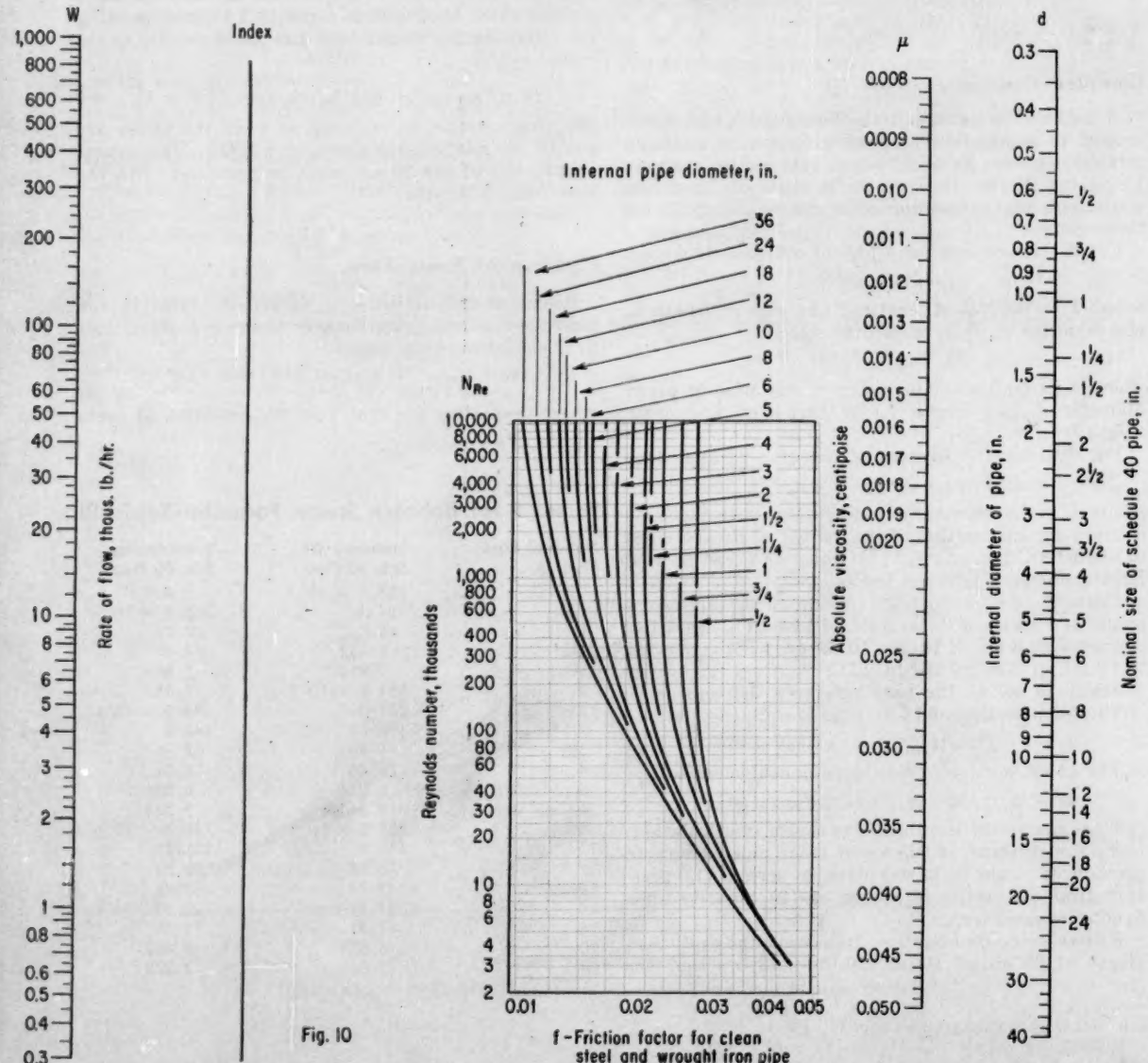


Fig. 10

Design Steps for Sonic Flow

For pipe size at given capacity and pressure drop,

1. Assume a pipe diameter, and calculate velocity in ft./sec. using the given flow.
2. Calculate sonic velocity for fluid using Eq. (20).
3. If sonic velocity of step 2 is greater than calculated velocity of step 1, calculate line pressure drop using usual flow equations. If these velocities are equal, then calculated pressure drop is maximum for line using usual flow equations. If sonic velocity is less than velocity of step 1, reassume line size and repeat calculations.

It's also a trial-and-error problem to determine flow rate (capacity) for a given line size and fixed pressure drop. Capacities, however, are assumed, and the pressure drops are calculated to find a match for the given conditions of inlet pressure, calculating back from the outlet pressure.

To determine pressure at inlet of pipe system for fixed pipe size and flow rate,

1. Determine sonic velocity at outlet conditions, and check against a calculated velocity using flow rate. If sonic is the lower velocity it must be used as limiting, and capacity is limited to that corresponding to this velocity.
2. Using the lower velocity and corresponding capacity, calculate pressure drop by the usual equations. For greater accuracy start at the outlet end of the line, divide line into sections using physical properties

PRESSURE DROP in pipelines for compressible fluids.

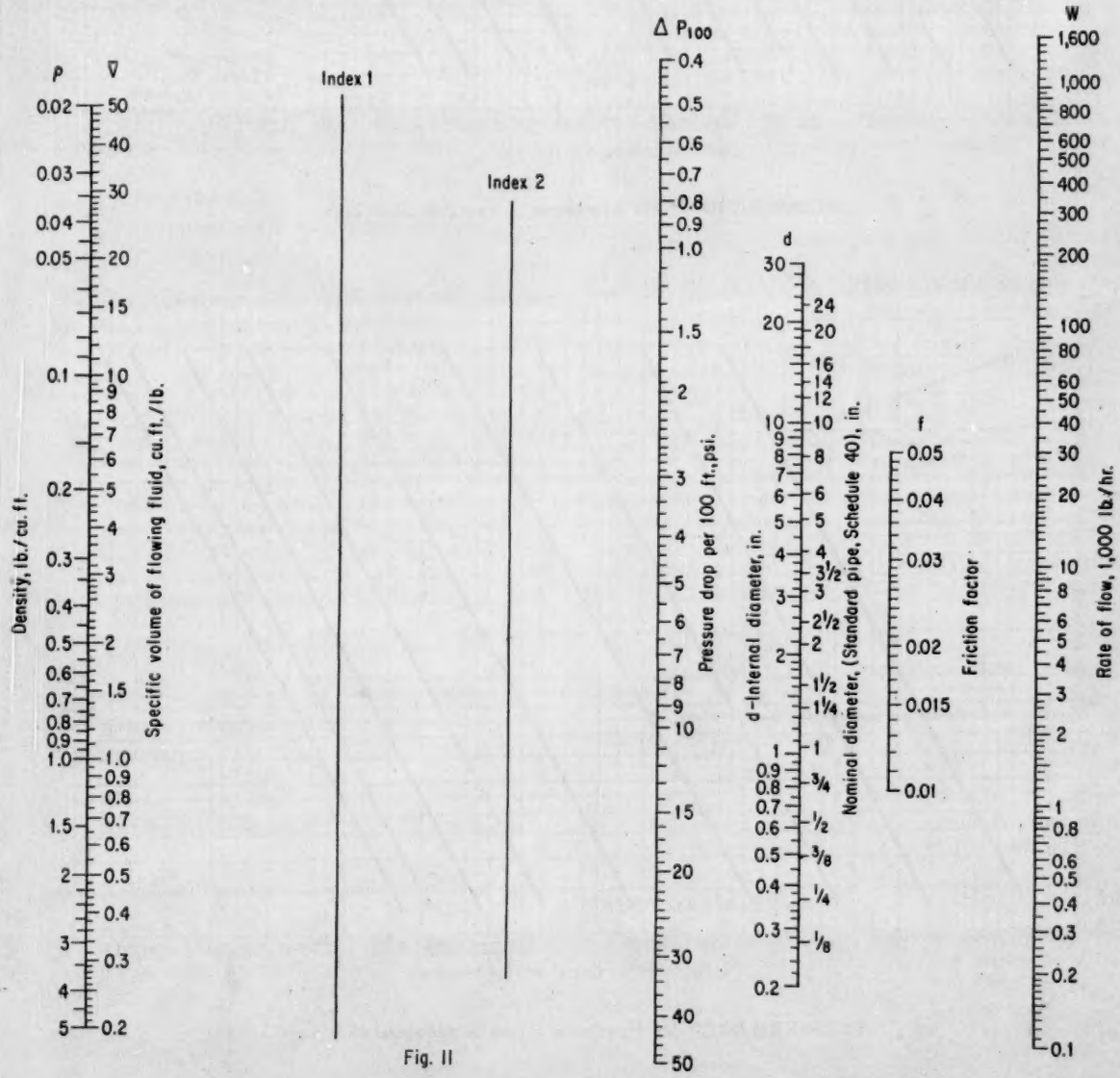
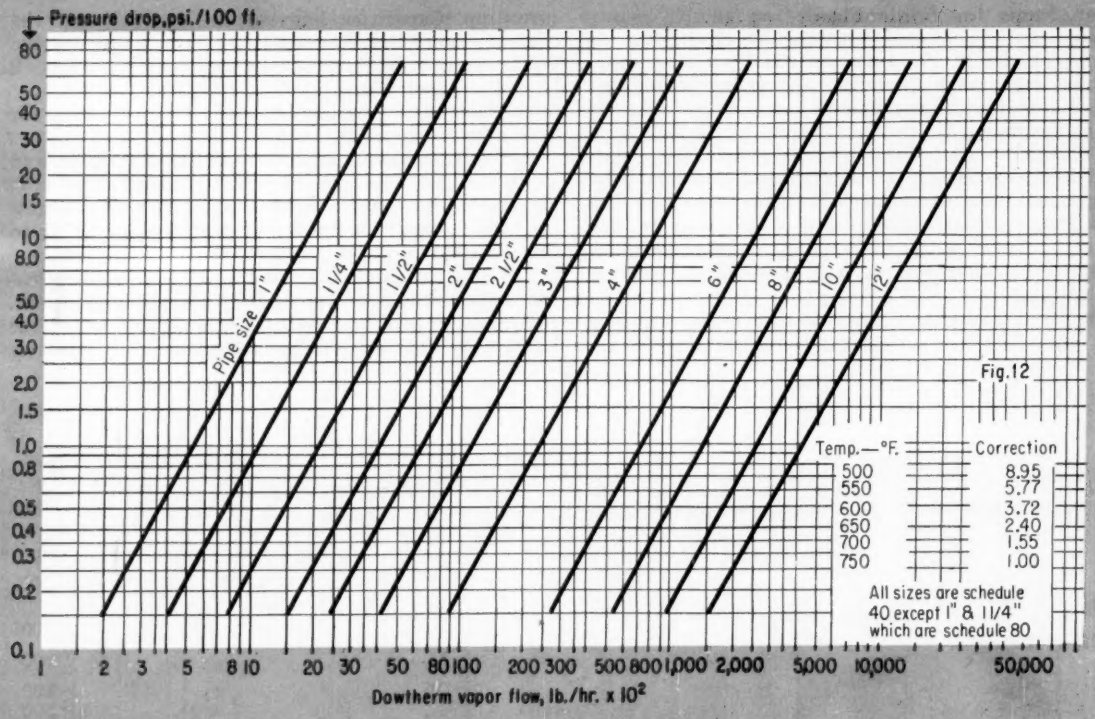
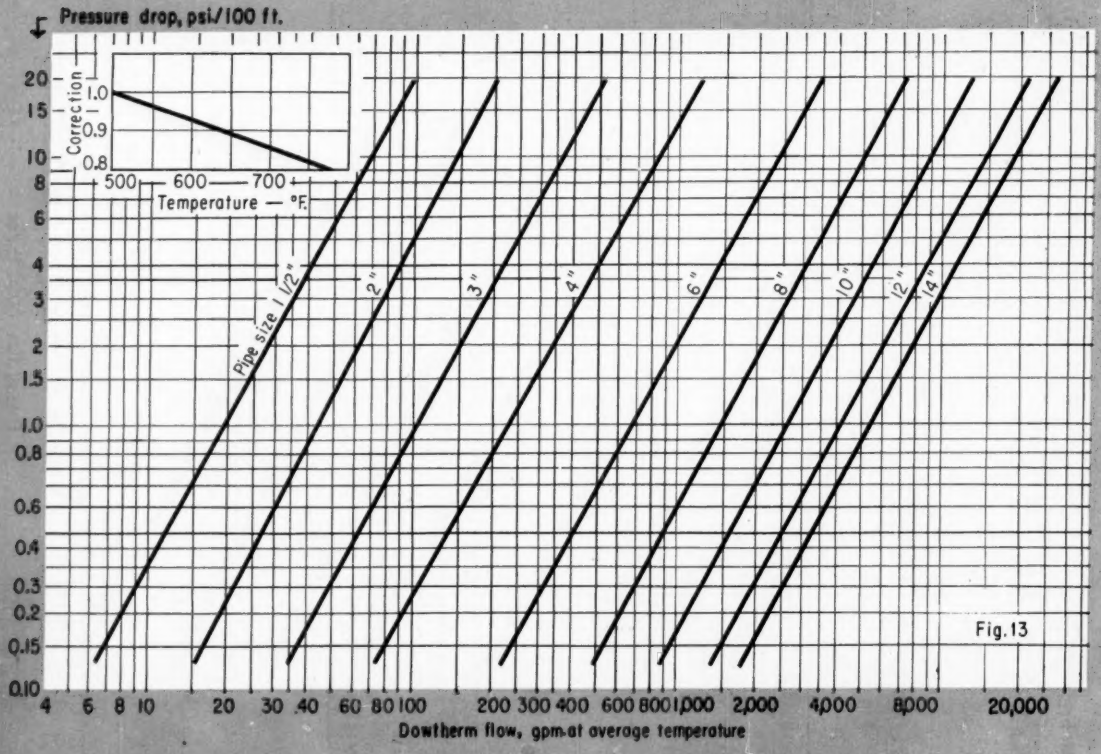


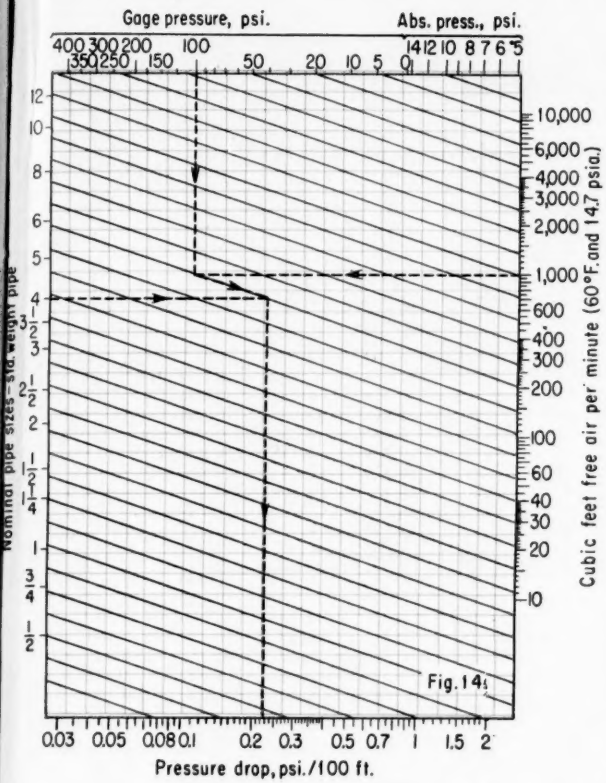
Fig. 11



PRESSURE DROP for Dowtherm A vapor in steel pipe.



PRESSURE DROP for Dowtherm liquid in Schedule 40 pipe.


Gage pressure, psi.
Abs. press., psi.
Nominal pipe sizes - std. weight pipe
Cubic feet free air per minute (60°F. and 14.7 psia.)
Fig. 14
Pressure drop, psi./100 ft.

PRESSURE DROP for compressed air.

of the system at these points, back up to the inlet end of the line for friction loss calculations.

This procedure is recommended particularly for steam turbine and similar equipment exhausting to atmosphere or vacuum. Pressure at the inlet of the line is the sum of discharge or outlet line pressure and all the incremental section pressure losses. For the case of a turbine, this sets outlet pressure, which is higher than pressure in the condenser or exhaust system.

Example 4—Water vapor, at 4,930 lb./hr., flows in a 3-in. line at 730 F. Outlet pressure is less than one-half inlet absolute pressure. Specific heats ratio, $c_p/c_v = 1.3$, and molecular weight of the vapor is 18.02. What is maximum flow that can be expected?

From Eq. (20),

$$v_s = [(1.3)\ (32.2)\ (1{,}544/18.02)\ (730 + 460)]^{0.5} = 2{,}065 \text{ ft./sec.}$$

Since cross-section of 3-in. pipe is 0.0513 sq.ft.,

$$\text{Volume flow} = (2{,}065)\ (0.0513) = 105.7 \text{ cu. ft./sec.}$$

$$\text{Vapor density} = 4{,}930/(3{,}600)\ (105.7) = 0.01295 \text{ lb./cu. ft.}$$

At end of line,

$$P = 0.01295\ (379/18.02)\ (14.7)\ (1{,}190/520) = 9.16 \text{ psia.}$$

Darcy Relation for Compressible Fluids

Calculation procedure is as follows:

1. Determine first estimate of line size by using suggested velocity from Table I.

2. Calculate Reynolds number. Determine friction factor f from Fig. 1 or Fig. 10 (latter for steel pipe). To use Fig. 10, connect W and μ. Connect index pivot with d. Read N_{Re}, use graph for f.

3. Determine total straight pipe length, L.

4. Determine equivalent pipe length for fittings.

5. Determine or assume losses through orifice plates, control valves, equipment, contraction and expansion.

6. Calculate (or use Fig. 11) pressure drop, $\Delta P/100$ ft. (Total ΔP must not exceed 0.1P, for line.) To use Fig. 11, connect W and d. Connect index 2 pivot with f. Connect index 1 pivot with $\overline{V}$. Read $\Delta P/100$.

$$\Delta P/100 = 0.000336\, fW^2/(\rho d^5) = 0.000000726\, fTS_g\,(q'_h)^2/(\rho d^5) \qquad (21)$$

7. For total pressure drop,

$$\Delta P = (L + \Sigma L_{eq.})\ (\Delta P/100) + \text{Item 5}$$

If total line or system drop is excessive, examine that drop due to pipe friction and that due to other factors in the system. If line drop is a small part of the total, little is gained by increasing pipe size. Consider reducing losses in item 5 above.

Fig. 12 is convenient when calculating Dowtherm vapor systems. Table IV can be used for most air problems. Note that both free air (60 F., 14.7 psia.) and compressed air (60 F., 100 psig.) are shown. Fig. 14 is useful for quick checking; however, above about 1,000 cu.ft./min. of free air its values are about 10% higher than the rational values of Table IV.

Flow Through Orifices

For liquids flowing through orifices with flange taps[7]

$$Q = 19.64\, d_o^2 C h_L^{0.5} = 236\, d_o^2 C\, (\Delta P/\rho)^{0.5} \qquad (22)$$

$$W = 157.6\, d_o^2 C\, (h_L \rho^2)^{0.5} \qquad (23)$$

Eqs. (24) and (25) hold for flow of compressible fluids through orifices with flange taps[7]

$$q_h' = 40{,}700\, Y d_o^2 C\, (\Delta P P_1'/T_1 S_g)^{0.5} \qquad (24)$$

$$W = 1{,}891\, Y d_o^2 C\, (\Delta P/V_1)^{0.5} \qquad (25)$$

Coefficient C is given in Fig. 15, Y is given in Fig. 16.

For an orifice installed in a steam line to limit steam flow, the following calculation, with accuracy satisfactory for engineering purposes, can be used[7]

• Pressure on discharge side of orifice is less than the critical pressure (58% of initial upstream pressure)[18]:

$$w = a P^{0.97}/s^{0.5} \qquad (26)$$

Multiply w by $1/(1 + 0.00065S^\circ)$ if steam is superheated.

• Pressure on discharge side of orifice is greater than the critical pressure[18]

$$w = 93.2\, a\, (H_1 - H_2)^{0.5}/\overline{V} \qquad (27)$$

where $\overline{V}$ is at final or discharge pressure, H_1 and H_2 read from steam chart following adiabatic expansion.

For discharge of air through an orifice, use Table V.

Two-Phase Fluid Flow

Concurrent flow of liquid and gas in pipe lines has received considerable study[1, 3, 4, 9], but pressure drop

Flow of Air Through Schedule 40 Steel Pipe—Table IV

Free air, Cu. Ft./Min.	Comp. Air, Cu. Ft./Min.,	Pressure Drop of Air, Psig./100 Ft. Sch. 40 Pipe								
		⅛"	¼"	⅜"	½"	¾"	1"	1¼"	1½"	2"
1	0.128	0.361	0.083	0.018						
2	0.256	1.31	0.285	0.064	0.020					
3	0.384	3.06	0.605	0.133	0.042					
4	0.513	4.83	1.04	0.226	0.071	¾"				
5	0.641	7.45	1.58	0.343	0.106	0.027				
6	0.769	10.6	2.23	0.408	0.143	0.037	1"			
8	1.025	18.6	3.89	0.848	0.255	0.062	0.019			
10	1.282	28.7	5.96	1.26	0.356	0.094	0.029			
15	1.922	.....	13.0	2.73	0.834	0.201	0.062	1¼"		
20	2.563	.....	22.8	4.76	1.43	0.345	0.102	0.026	1½"	
25	3.204	.....	35.6	7.34	2.21	0.526	0.156	0.039	0.019	
30	3.845	.....	.....	10.5	3.15	0.748	0.219	0.055	0.026	
35	4.486	.....	.....	14.2	4.24	1.00	0.293	0.073	0.035	
40	5.126	.....	.....	18.4	5.49	1.30	0.379	0.095	0.044	
45	5.767	.....	.....	23.1	6.90	1.62	0.474	0.116	0.055	2"
50	6.408	.....	.....	28.5	8.49	1.99	0.578	0.149	0.067	0.019
60	7.690	.....	.....	40.7	12.2	2.85	0.819	0.200	0.094	0.027
70	8.971	2½"	.....	.....	16.5	3.83	1.10	0.270	0.126	0.036
80	10.25	0.019	.....	.....	21.4	4.96	1.43	0.350	0.162	0.046
90	11.53	0.023	.....	.....	27.0	6.25	1.80	0.437	0.203	0.058
100	12.82	0.029	.....	.....	33.2	7.69	2.21	0.534	0.247	0.070
125	16.02	0.044	3"	.....	.....	11.9	3.39	0.825	0.380	0.107
150	19.22	0.062	0.021	.....	.....	17.0	4.87	1.17	0.537	0.151
175	22.43	0.083	0.028	.....	.....	23.1	6.60	1.58	0.727	0.205
200	25.63	0.107	0.036	3½"	.....	30.0	8.54	2.05	0.937	0.264
225	28.84	0.134	0.045	0.022	.....	37.9	10.8	2.59	1.19	0.331
250	32.04	0.164	0.055	0.027	.....	.....	13.3	3.18	1.45	0.404
275	35.24	0.191	0.066	0.032	.....	.....	16.0	3.83	1.75	0.484
300	38.45	0.232	0.078	0.037	.....	.....	19.0	4.56	2.07	0.573
325	41.65	0.270	0.090	0.043	.....	.....	22.3	5.32	2.42	0.673
350	44.87	0.313	0.104	0.050	4"	.....	25.8	6.17	2.80	0.776
375	48.06	0.356	0.119	0.057	0.030	.....	29.6	7.05	3.20	0.887
400	51.26	0.402	0.134	0.064	0.034	.....	33.6	8.02	3.64	1.00
425	54.47	0.452	0.151	0.072	0.038	.....	37.9	9.01	4.09	1.13
450	57.67	0.507	0.168	0.081	0.042	.....	.....	10.2	4.59	1.26
475	60.88	0.562	0.187	0.089	0.047	.....	.....	11.3	5.09	1.40
500	64.08	0.623	0.206	0.099	0.052	.....	.....	12.5	5.61	1.55
550	70.49	0.749	0.248	0.118	0.062	.....	.....	15.1	6.79	1.87
600	76.90	0.887	0.293	0.139	0.073	.....	.....	18.0	8.04	2.21
650	83.30	1.04	0.342	0.163	0.086	5"	.....	21.1	9.43	2.60
700	89.71	1.19	0.395	0.188	0.099	0.032	.....	24.3	10.9	3.00
750	96.12	1.36	0.451	0.214	0.113	0.036	.....	27.9	12.6	3.44
800	102.5	1.55	0.513	0.244	0.127	0.041	.....	31.8	14.2	3.90
850	108.9	1.74	0.576	0.274	0.144	0.046	.....	35.9	16.0	4.40
900	115.3	1.95	0.642	0.305	0.160	0.051	6"	40.2	18.0	4.91
950	121.8	2.18	0.715	0.340	0.178	0.057	0.023	.....	20.0	5.47
1,000	128.2	2.40	0.788	0.375	0.197	0.063	0.025	.....	22.1	6.06
1,100	141.0	2.89	0.948	0.451	0.236	0.075	0.030	.....	26.7	7.29
1,200	153.8	3.44	1.13	0.533	0.279	0.089	0.035	.....	31.8	8.63
1,300	166.6	4.01	1.32	0.626	0.327	0.103	0.041	.....	37.3	10.1
1,400	179.4	4.65	1.52	0.718	0.377	0.119	0.047	.....	.....	11.8
1,500	192.2	5.31	1.74	0.824	0.431	0.136	0.054	.....	.....	13.5
1,600	205.1	6.04	1.97	0.932	0.490	0.154	0.061	.....	.....	15.3
1,800	230.7	7.65	2.50	1.18	0.616	0.193	0.075	8"	.....	19.3
2,000	256.3	9.44	3.06	1.45	0.757	0.237	0.094	0.023	.....	23.9
2,500	320.4	14.7	4.76	2.25	1.17	0.366	0.143	0.035	10"	37.3
3,000	384.5	21.1	6.82	3.20	1.67	0.524	0.204	0.051	0.016	.....
3,500	448.6	28.8	9.23	4.33	2.26	0.709	0.276	0.068	0.022	.....
4,000	512.6	37.6	12.1	5.66	2.94	0.919	0.358	0.088	0.028	.....
4,500	576.7	47.6	15.3	7.16	3.69	1.16	0.450	0.111	0.035	12"
5,000	640.8	.....	18.8	8.85	4.56	1.42	0.552	0.136	0.043	0.018
6,000	769.0	.....	27.1	12.7	6.57	2.03	0.794	0.195	0.061	0.025
7,000	897.1	.....	36.9	17.2	8.94	2.76	1.07	0.262	0.082	0.034
8,000	1,025	.....	.....	22.5	11.7	3.59	1.39	0.339	0.107	0.044
10,000	1,282	.....	.....	35.2	18.4	5.60	2.16	0.526	0.164	0.067
12,000	1,538	.....	.....	.....	26.4	8.07	3.09	0.753	0.234	0.096
14,000	1,794	.....	.....	.....	36.0	11.0	4.21	1.02	0.316	0.129
16,000	2,051	.....	.....	.....	.....	14.3	5.50	1.33	0.411	0.167
18,000	2,307	.....	.....	.....	.....	18.2	6.96	1.68	0.520	0.213
20,000	2,563	.....	.....	.....	.....	22.4	8.60	2.01	0.642	0.260
22,000	2,820	.....	.....	.....	.....	27.1	10.4	2.50	0.771	0.314
24,000	3,076	.....	.....	.....	.....	32.3	12.4	2.97	0.918	0.371
26,000	3,332	.....	.....	.....	.....	37.9	14.5	3.49	1.12	0.435
28,000	3,588	.....	.....	.....	.....	.....	16.9	4.04	1.25	0.505
30,000	3,845	.....	.....	.....	.....	.....	19.3	4.64	1.42	0.520

prediction is not extremely reliable except for several gas pipe-line "special cases." General determination of pressure drop for plant process lines can only be approximated.

Six or seven types of flow patterns (Fig. 17) are usually considered in evaluating two-phase flow, but only one type can exist in a line at a given time. As flow conditions—e.g., velocity, roughness, elevation—change, however, the flow may change from one type to another. Unit pressure drop varies significantly among the several types.

Here, briefly is name and description of each of the two-phase flow types shown in Fig. 17[1]:

- *Bubble* or *froth*—bubbles dispersed in liquid.
- *Stratified*—liquid and gas flow in stratified layers.
- *Wave*—gas flows in top of pipe section, liquid in waves in lower section.
- *Slug*—slugs of gas bubbles flow through the liquid.
- *Annular*—liquid flows in continuous annular ring on pipe wall; gas flows through center of pipe.
- *Plug*—plugs of liquid flow separated by plugs of gas.
- *Dispersed*—gas and liquid dispersed.

Calculate Two-Phase Flow Drop

Pressure drop for a system of horizontal and vertical, or inclined, pipe is the sum of the horizontal pressure drop plus additional drop attributable to each vertical rise, regardless of initial and final elevations of the line.[1]

$$\Delta P_{TPH} = \Delta P_{TP} L + n h F_s \rho_L / 144 \qquad (28)$$

1. Calculate $W_m \lambda \psi / G$, where $\lambda = [(\rho_g/0.075)(\rho_L/62.3)]^{\frac{1}{2}}$ and $\psi = (73/\gamma)[\mu_L(62.3/\rho_L)^2]^{1/3}$.

Calculate G/λ.

In Fig. 17, read intersection of ordinate and abscissa to identify probable type of flow. Since this plot is not an exact division of flow types, adjacent flow types should be recorded also.

2. Calculate the separate liquid and gas flow pressure drops. For general process application both ΔP_L and ΔP_g can be calculated by the general flow equation

$$\Delta P = 3.36 f L W^2 (10^{-9})/d^5 \rho \qquad (29)$$

using pertinent values for each. For an assumed line size d, f is obtained from the Reynolds number-friction factor chart, Fig. 1.

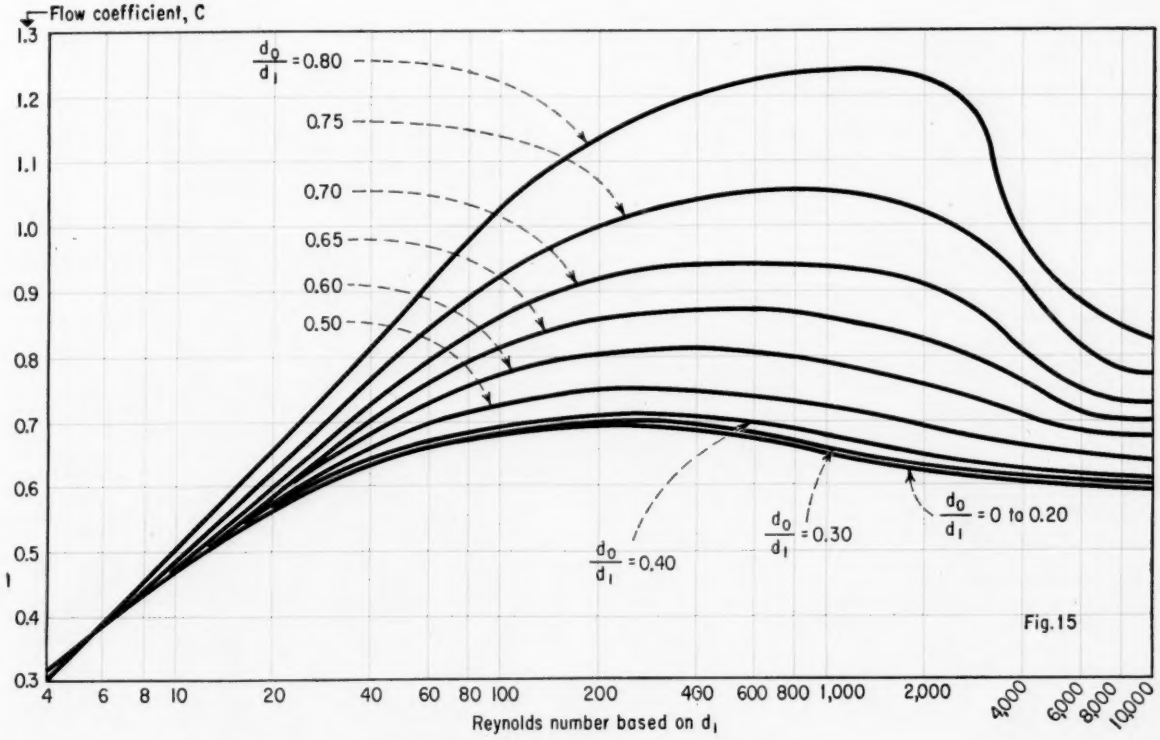
3. Calculate

$$X = (\Delta P_L / \Delta P_g)^{0.5} \qquad (30)$$

4. Calculate ϕ_{GTT} for types of flow selected from Fig. 17[1]

Type Flow	ϕ_{GTT}
Froth or bubble	$14.2\, X^{0.75}/L^{0.1}$
Plug	$27.315\, X^{0.855}/L^{0.17}$
Stratified	$15{,}400\, X/L^{0.5}$
Slug	$1{,}190\, X^{0.315}/L^{0.5}$
Annular	$(4.8 - 0.3125\, d)\, X^{0.343-0.21d}$

For annular flow, set $d = 10$ for any pipe larger than 10 in.



ORIFICE COEFFICIENT for liquid flow.

5. Calculate two-phase pressure drop for horizontal portions of lines. For all types of two-phase flow except wave and fog,

$$\Delta P_{TP} = \Delta P_g \phi_{GTT}^2 \quad (31)$$

For wave flow,[10]

$$\Delta P_{TP} = f_{TP} (G_g')^2/(193.2\, d\rho_g) \quad (32)$$

$$f_{TP} = 0.0043\, (W_m \mu_L/G\mu_g)^{0.214} \quad (33)$$

6. Total two-phase pressure drop, including horizontal and vertical sections of line. Multiply calculated value by 1.1-2.0 depending upon critical nature of application.

$$\Delta P_{TPH} = \Delta P_{TP} L + nhF_e\, \rho_L/144 \quad (34)$$

where ρ_L is density, lb./cu.ft., of liquid flowing in the line, and F_e is elevation factor using gas velocity v. For v greater than 10,

$$F_e = 0.00967\, W_m^{0.5}/v^{0.7} \quad (35)$$

$$F_e = 1.7156\, V_g^{-0.702} \quad (35a)$$

Use Fig. 18 for v less than 10. Most gas transmission lines flow at 1-15 ft./sec.

For fog or spray-type flow, Baker[1] suggests using Martinelli's correlation and multiplying results by two.[11]

Two-Phase Flow Problem

Example 5—A liquid-vapor mixture is to flow in a Schedule 40 steel line having 358 ft. of level pipe and three vertical rises of 10 ft. each, plus one 50-ft. vertical rise. Evaluate type of flow and expected pressure drop. System conditions and properties include: vapor flow is 3,000 lb./hr.; liquid flow is 1,000 lb./hr.; density of vapor is 0.077 lb./cu.ft., of liquid is 63.0 lb./cu.ft.; viscosity of vapor is 0.00127 cp., of liquid is 1.0 cp.; surface tension of liquid is 15 dyne/cm. Maximum allowable vapor velocity is 15,000 ft./min.

1. Determine probable types of flow.

$$\lambda = (0.077/0.075)^{0.5}\, (63.0/62.3)^{0.5} = 1.017$$

$$\psi = (73/15)\, [1.0\, (62.3/63.0)^2]^{0.33} = 4.86$$

Try 3-in. pipe, cross-section of 0.0513 sq.ft.

$$W_m = 1{,}000/0.0513 = 19{,}494 \text{ lb./(hr.) (sq. ft.)}$$

$$G = 3{,}000/0.0513 = 58{,}482 \text{ lb./(hr.) (sq. ft.)}$$

$$W_m \lambda \psi/G = 19{,}494\, (1.017)\, (4.86)/58{,}482 = 1.641$$

$$G/\lambda = 58{,}482/1.017 = 57{,}500$$

Reading from Fig. 17, flow pattern is probably annular, but it could be wave or dispersed depending on many undefined and unknown conditions.

2. Calculate liquid and gas pressure drops.

For liquid pressure drop, determine N_{Re} for 3-in. pipe. From Fig. 2, ϵ/d is 0.0006 for steel pipe.

$$v = 1{,}000/63\, (3{,}600)\, (0.0513) = 0.086 \text{ ft./sec.}$$

$$\mu_e = 1 \text{ cp.}/1{,}488 = 0.000672 \text{ lb./(ft.) (sec.)}$$

$$D = 3.068/12 = 0.2557 \text{ ft.}$$

$$N_{Re} = Dv\rho/\mu_e = 0.2557\, (0.086)\, (63.0)/0.000672 = 2{,}060$$

This value is in critical region of Fig. 1; $f = 0.0576$.

$$\Delta P_L = 3.36\, fLW^2\, (10^{-6})/d^5\rho$$

$$= 3.36\, (0.0576)\, (1{,}000)^2\, (10^{-6})/(3.068)^5\, (63)$$

$$= 1.1 \times 10^{-5} \text{ psi./ft.}$$

For gas pressure drop,

$$v = 3{,}000/0.077\, (3{,}600)\, (0.0513) = 211 \text{ ft./sec.}$$

$$\mu_e = 0.00127/1{,}488 = 0.000000854 \text{ lb./(ft.) (sec.)}$$

$$N_{Re} = Dv\rho/\mu_e = 0.2557\, (211)\, (0.077)/0.000000854$$

$$= 4.9 \times 10^6$$

for which, from Fig. 1, $f = 0.0175$.

$$\Delta P_g = 3.36\, (0.0175)\, (3{,}000)^2\, (10^{-6})/(3.068)^5\, (0.077)$$

$$= 0.0254 \text{ psi./ft.}$$

3. Calculate square root of pressure drop ratio.

$$X = (\Delta P_L/\Delta P_g)^{0.5}$$

$$= [(1.1 \times 10^{-5})/(2.54 \times 10^{-2})]^{0.5}$$

$$= 0.0210$$

4. For annular flow,

$$\phi_{GTT} = (4.8 - 0.3125\, d)\, X^{0.343 - 0.021 d}$$

$$= 1.31$$

5. Two-phase flow for horizontal runs,

$$\Delta P_{TP} = \Delta P_g \phi_{GTT}^2 = (0.0254)\, (1.31)^2 = 0.0438 \text{ psi./ft.}$$

6. For vertical elevation pressure drop,

$$F_e = 0.00967\, (W_m)^{0.5}/v^{0.7}$$

$$= 0.00967\, (19{,}494)^{0.5}/(211)^{0.7}$$

$$= 0.032$$

For the pressure drop,

$$nhF_e\rho_L/144 = [(3)\, (10) + (1)\, (50)]\, (0.032)\, (63)/144$$

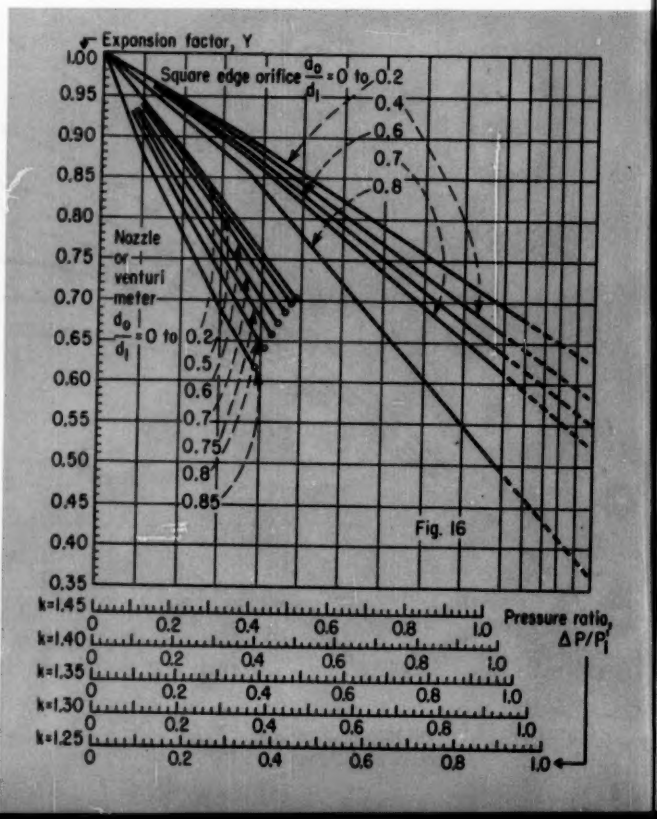
$$= 1.125 \text{ psi.}$$

Total pressure drop for the line is

$$\Delta P_{TPH} = (0.0438)\, (358) + 1.125$$

$$= 16.7 \text{ psi.}$$

These calculations are somewhat uncertain because of lack of exact correlations, so calculate pressure drop for other flow patterns, and apply a generous safety factor to the final results. Based on average field experience, it's probably good practice to evaluate pressure drop for the highest condition anticipated.



ORIFICE FACTOR for gas flow.

Flow of Gas Being Heated

Maker[11] presents a valuable summary of pressure drop determinations in tubular heaters. Ludwig's direct approach[12] gives good results, being only about 10% high for the usual situation.

$$P_1^2 - P_2^2 = (0.811\ W_t^2/D^5)\ (P_1\overline{V}_1 + P_2\overline{V}_2)\ f\ (L_{eq.\,2} - L_{eq.\,1}) + 2.8\ (10^{-7})\ W_t^2\overline{V}/d^4 \qquad (36)$$

where the last term, often neglected, adds velocity pressure at outlet of the tube. The friction factor f is based upon the gas at average flowing conditions—0.02 is a good assumption for it. PV is linear with respect to equivalent length $L_{eq.}$, because heat absorbed/lin.ft. is considered constant. Knowing outlet enthalpy, $P_2\overline{V}_2$ and the rate of heat absorption/ft., the value of $P_1\overline{V}_1$ can be calculated and, from Eq. (36), P_1 can be determined.

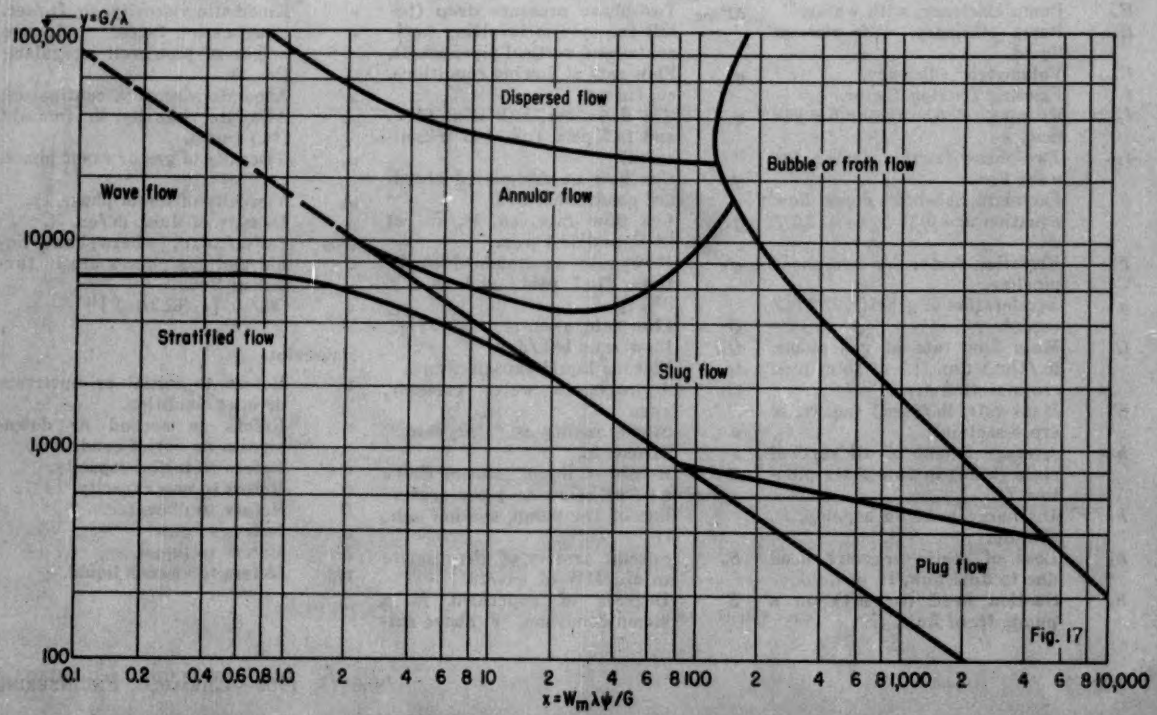
Flow of Evaporating Liquid

The following useful relation[12, 14] has given good results for flow of evaporating liquid, compared to longer methods. It's reported[14] not to hold well for low-pressure steam—say, below 30 psia.—or low-pressure (vacuum) distillation. In other cases it has checked well under high vacuum involving water vapor.

$$P_1^2 - P_2^2 = [3.36\ (10^{-6})\ W_t^2/D^5]\ (P_1\overline{V}_1 + P_2\overline{V}_2)\ f\ (L_{eq.\,2} - L_{eq.\,1})$$

The relation of $P_1\overline{V}_1$ to length is not the same as for that of a gas being heated. The point of initial vaporization of liquid in the furnace tube is usually unknown. It must be determined by trial and error starting with an assumed point and physical properties of the liquid and vapor at process condition, which condition is representative of point where vaporization begins and the tube outlet.

1. Since P_1, L_1 and V_1 are unknown, assume a value or point for initial vaporization at the inlet end of the tube. (Value of $P_1\overline{V}_1$ can usually be neglected.)
2. Calculate from Eq. (37) the value of P_1 using equivalent length of tube, including bends, headers, etc., $L_{eq.2} - L_{eq.1}$.
3. This calculated pressure should correspond to the boiling point of the liquid at inlet conditions. Also P_1 can be checked on a plot, or from a table, of enthalpy vs. pressure.
4. If the calculated P_1 does not check, assume another value for pressure (or temperature) and recalculate $(L_{eq.2} - L_{eq.1})$. Subtract this length from the total equivalent length of the tube to determine distance from the inlet where vaporization begins.
5. From the change in enthalpy, or total heat, over the entire tube per equivalent length, Btu./(lb.) $(\text{ft.})_{eq.}$, calculate the heat change for length of item 4. If this agrees with the assumed conditions, the point of initiation of vaporization has been determined. If not, reassume values and recalculate.
6. Pressure drop for the liquid from the inlet of tube to the point calculated in item 5 can be determined by usual equations for fluid flow, as covered earlier in this report.
7. When velocity pressure $(= 2.8 \times 10^{-7}\ W_t^2\overline{V}/d^4)$ is appreciable, it should be added to the calculated pressure drop of item 4 or 5 after the balance has been attained. This will give a close value to the correct



TYPES OF FLOW for two-phase systems.

Nomenclature

a	Area of cross-section, sq. in.
a_o	Area of orifice, sq. in.
B_d	Bell diameter of vertical pump, ft.
c	Cycle of reciprocating pump.
c_p	Specific heat of liquid, Btu./(lb.) (°F.).
c_p/c_v	Ratio of specific heat at constant pressure to that at constant volume.
C	Orifice flow coefficient.
C_E	Viscosity correction for efficiency, to convert to water performance.
C_H	Viscosity correction for head, to convert to water performance.
C_Q	Viscosity correction for capacity, to convert to water performance.
d	Inside diameter of pipe, in.
d	Impeller diameter, in.
d_e	Equivalent or reference pipe diameter, in.
d_o	Diameter of orifice, in.
d_p	Diameter of piston or plunger, in.
d_r	Diameter of piston rod, in.
d'	Liquid displacement, cu. ft./min.
d''	Theoretical displacement, cu. ft./min.
D	Inside diameter of pipe, ft.
D	Height of liquid (static) above (+) or below (−) the centerline of the pump, on discharge side, ft.
E	Efficiency factor, varies with line size and condition.
E	Pump efficiency.
E_a	Fraction entrained gas by volume at 1 atm.
E_w	Pump efficiency, with water.
E_{vis}	Pump efficiency, with viscous liquid.
E_{vol}	Volumetric efficiency.
f	Fanning friction factor.
f_g	Fanning friction factor for gas flow.
f_{TP}	Two-phase friction factor for wave flow.
F	Factor in Babcock's steam flow equation $= 0.0131 \times (\rho + 3.6)/d^5$.
F_e	Elevation factor for two-phase pipeline.
g	Acceleration of gravity, 32.2 ft./(sec.)^2.
G	Mass flow rate of gas phase, lb./(hr.) (sq. ft.) of total pipe cross-section area.
G'	Mass rate, lb./(sec.) (sq. ft. of cross-section).
h	Average height of all vertical rises (hills) in two-phase pipeline, ft.
h_D	Discharge head on a pump, ft. of fluid.
h_L	Loss of static pressure head due to fluid flow, ft. of fluid.
h_s	Suction head (or lift) on a pump, ft. of fluid.
h_v	Velocity head, ft. of fluid.
h_{sL}	Friction losses in pipe and fittings, suction line, ft. of fluid.
h_{DL}	Friction losses in pipe and fittings, discharge line, ft. of fluid.
H	Total heat, Btu./lb.
H	Total head developed by a pump, ft. of fluid.
H_w	Approximate water equivalent head, ft.
H_{vis}	Head of viscous fluid, ft.
K	Coefficient in velocity head equation.
l	Water depth in pump, ft.
L	Pipe length, ft.
L_e	Equivalent length of line of one size referred to another size, miles or ft.
L_{eq}	Equivalent length of straight pipe, ft.
L_m	Length of pipe, mi.
MW	Molecular weight.
n	Number of vertical rises (hills) in two-phase pipeline flow.
n	Rotative speed, rpm.
N_p	Number of pumps.
N_{Re}	Reynolds number.
N_s	Specific speed.
P, P_a	Atmospheric pressure, or absolute pressure, psia.
p'_{vp}	Vapor pressure of liquid at pumping temperature, ft. of fluid.
p'_a	Atmospheric or absolute pressure, ft. of fluid.
P_{vp}	Vapor pressure of liquid at pumping temperature, psia.
P_s	Standard pressure for gas measurement, psia.
ΔP	Pressure drop, psi.
ΔP_{TP}	Two-phase pressure drop for horizontal portion, psi./ft.
ΔP_{TPH}	Two-phase pressure drop (total) for system involving horizontal and vertical pipe, psi./ft.
q	Flow rate at flowing conditions, cu. ft./sec.
q_d	Gas flow rate, MCFD at 60 F. and 14.7 psia. (or 14.65 if indicated).
q_{d_s}	Gas flow at designated standard conditions, CFD.
q_h	Gas flow rate, cu. ft./hr., at 60 F. and 14.4 psia.
q'_n	Flow rate at standard conditions (14.7 psia., and 60 F.), SCFH.
Q	Flow rate, gpm.
Q_b	Flow rate, bbl./day.
Q_{vis}	Viscous liquid capacity, gpm.
Q_w	Approximate water capacity, gpm.
s	Steam quality as % dryness.
s	Stroke, in.
S	Height of liquid (static) above (+) or below (−) the centerline of the pump, suction side, ft.
S_g	Specific gravity of gas relative to air, MW of gas/29.
$S°$	Degrees of superheat in a steam condition, °F. above saturated, (not actual temperature).
$Sp.\ Gr.$	Specific gravity of liquid at pumping temperature, referred to water as 1.0.
t	Temperature, °F.
t	Piston speed or travel, ft./min.
Δt	Temperature rise, °F.
T	Absolute temperature, deg. R.
T_s	Standard temperature for gas measurement, °R.
v	Flow velocity (mean), or superficial velocity in pipelines at flowing conditions for entire pipe cross-section, ft./sec.
v_c	Sonic (critical) velocity in compressible fluid, ft./sec.
V	Specific volume of fluid, cu. ft./lb.
V	Free air flow, cu. ft./sec. at 60 F. and 14.7 psia.
w	Flow rate, lb./min.
W	Flow rate, lb./hr.
W	Width of channel with series pump, ft.
W_m	Mass flow rate of liquid phase, lb./(hr.) (sq. ft.) of total pipe cross-section area.
W_s	Flow rate, lb./sec.
W_t	Mass flow rate, lb./(hr.) (tube).
x	Fraction of initial line parallel with new line.
X	$(\Delta P_L/\Delta P_g)^{\frac{1}{2}}$
Y	Expansion factor through orifices for compressible flow.
Z	Compressibility factor for gases.
γ	Surface tension of liquid, dynes/cm.
Δ	Difference.
λ	$[(\rho_g/0.075)\ (\rho_L/62.3)]^{\frac{1}{2}}$
ν	Kinematic viscosity, sq. ft./sec.
ϵ	Roughness factor, effective height of pipe wall irregularities, ft.
μ	Absolute viscosity, centipoises.
μ_a	Absolute viscosity, lb. (mass)/(ft.) (sec.).
μ_g	Viscosity of gas or vapor phase, cp.
μ_L	Viscosity of liquid phase, cp.
ρ	Density of fluid, lb./cu. ft.
ϕ_{DTT}	$(\Delta P_{TP}/\Delta P_g)^{\frac{1}{2}}$, where both liquid and gas phases are in turbulent flow.
ψ	$(73/\gamma)\ [\mu_L(62.3/\rho_L)^2]^{\frac{1}{8}}$

Subscripts

1	Refers to initial or upstream or inlet condition.
2	Refers to second or downstream or outlet condition.
a	Refers to initial capacity.
b	Refers to new capacity.
D	Refers to diameter.
g	Refers to gas.
L	Refers to liquid.
vis	Refers to viscous liquid.

Discharge of Air Through Orifice–Table V

Pressure before orifice, psig.	Diameter of Orifice, In. 1/64	1/32	1/16	1/8	1/4	3/8	1/2	5/8	3/4	7/8	1
	Discharge of Free Air, Cu. Ft./Min.										
1	0.028	0.112	0.450	1.80	7.18	16.2	28.7	45.0	64.7	88.1	115
2	0.040	0.158	0.633	2.53	10.1	22.8	40.5	63.3	91.2	124	162
3	0.048	0.194	0.775	3.10	12.4	27.8	49.5	77.5	111	152	198
4	0.056	0.223	0.892	3.56	14.3	32.1	57.0	89.2	128	175	228
5	0.062	0.248	0.993	3.97	15.9	35.7	63.5	99.3	143	195	254
6	0.068	0.272	1.09	4.34	17.4	39.1	69.5	109	156	213	278
7	0.073	0.293	1.17	4.68	18.7	42.2	75.0	117	168	230	300
9	0.083	0.331	1.32	5.30	21.2	47.7	84.7	132	191	260	339
12	0.095	0.379	1.52	6.07	24.3	54.6	97.0	152	218	297	388
15	0.105	0.420	1.68	6.72	26.9	60.5	108	168	242	329	430
20	0.123	0.491	1.96	7.80	31.4	70.7	126	196	283	385	503
25	0.140	0.562	2.25	8.98	35.9	80.9	144	225	323	440	575
30	0.158	0.633	2.53	10.1	40.5	91.1	162	253	365	496	648
35	0.176	0.703	2.81	11.3	45.0	101	180	281	405	551	720
40	0.194	0.774	3.10	12.4	49.6	112	198	310	446	607	793
45	0.211	0.845	3.38	13.5	54.1	122	216	338	487	662	865
50	0.229	0.916	3.66	14.7	58.6	132	235	366	528	718	938
60	0.264	1.06	4.23	16.9	67.6	152	271	423	609	828	1,082
70	0.300	1.20	4.79	19.2	76.7	173	307	479	690	939	1,227
80	0.335	1.34	5.36	21.4	85.7	193	343	536	771	1,050	1,371
90	0.370	1.48	5.92	23.7	94.8	213	379	592	853	1,161	1,516
100	0.406	1.62	6.49	26.0	104	234	415	649	934	1,272	1,661
110	0.441	1.76	7.05	28.2	113	254	452	705	1,016	1,383	1,806
120	0.476	1.91	7.62	30.5	122	274	488	762	1,097	1,494	1,951
125	0.494	1.98	7.90	31.6	126	284	506	790	1,138	1,549	2,023

Table is based on 100% coefficient of flow. For well rounded entrance, multiply values by 0.97. For sharp-edged orifices use multiplier of 0.65.

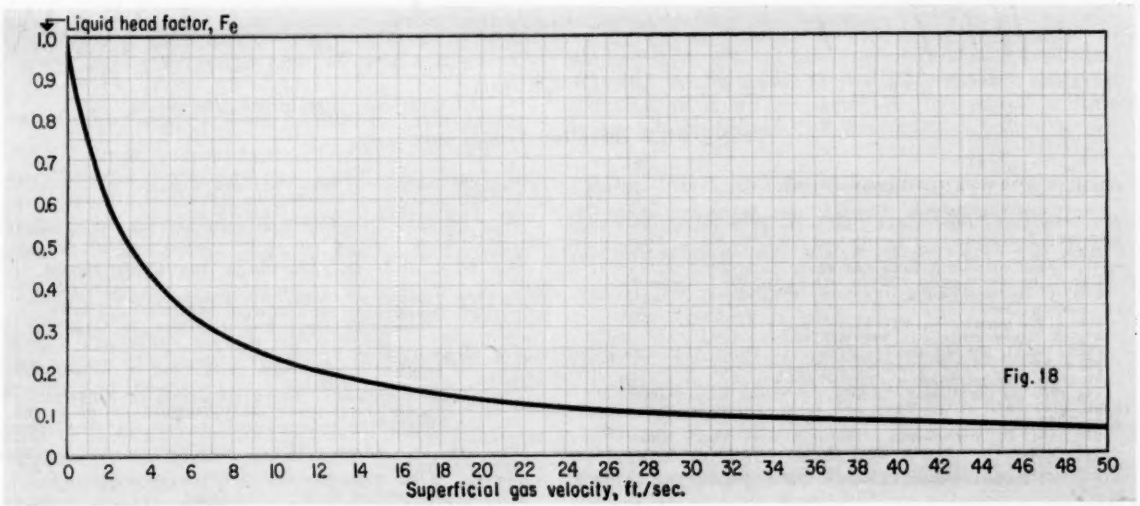
total pressure drop for the vaporization end of the tube.

A step-wise sectional calculation for this problem has also been proposed by Chenoweth and Martin.[4]

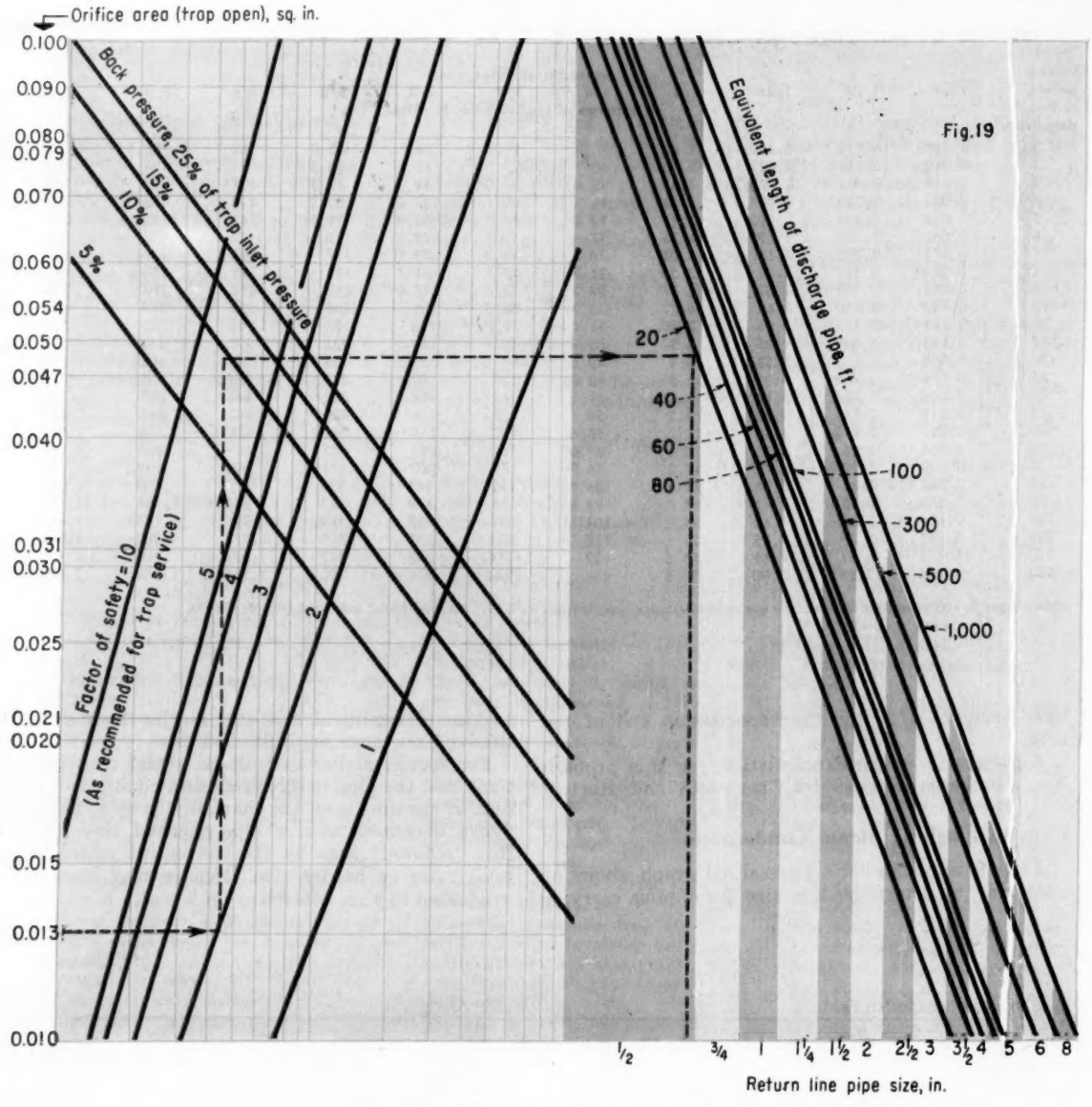
Flow of Flashing Steam Condensate

Fig. 19, although not a generalized graph, shows an easy way to determine line size for piping carrying flashing steam-liquid mixtures flowing from traps or similar blow-down or drain devices.

For header sizing in multiple steam trap installations, add the total orifice areas and handle as a single line. If the area is off the chart, divide by a convenient figure, determine area of pipe required, then multiply this "reduced" area by the convenient figure to get total main or header size. Header may have to be graduated in size, depending on layout.



ELEVATION FACTOR for friction loss calculations.



LINE SIZE chart for flashing mixtures.

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pumping of fluids

How to select pumps that meet your performance requirements for moving liquids through process lines.

The almost universal denominator in gas plants, chemical plants, petrochemical plants and petroleum refineries is the pumping of liquids.

As part of the over-all design for these chemical process industry plants, engineers will be called upon to select, specify and design pumps and pumping systems that direct the flow of fluids within and through the plant.

Many kinds and sizes of pumps have been developed by equipment manufacturers to satisfy the many special conditions found in chemical process plants. However, since all of these cannot be discussed here, please note that the omission of some types does not mean that they may not be suitable for a specific service.

In general, final pump selection and performance details are recommended by the manufacturers to meet the conditions specified by the process design engineer. It is important that the engineer who designs a process piping system be completely familiar with the action of each pump offered for a particular service so that he can evaluate properly such items as control instruments and valves in the full knowledge of the entire *system* requirements.

This second section of a 48-page report on process design for flow of fluids will discuss: pump selection; design of pumping systems; and the choice of materials of construction for pumps and pumping systems.

Centrifugal Pumps: Most Common Type Today

Of the three general types of pumps—centrifugal, rotary and reciprocating—the use of centrifugals has grown rapidly in recent years. Today the centrifugal pump is the most common variety to be found in a chemical process plant. Thus, we begin our discussion with centrifugals.

The centrifugal pump develops its pressure by imposing a centrifugal force on the liquid passing through the pump. General application is in installations where the design specifications call for high capacity and low-to-medium head.

To satisfy pump discharge-head (or pressure) requirements the designer may specify a multistage (impellers) unit instead of a single-stage pump. Since the conditions of use can vary all the way from pumping water to pumping hot light hydrocarbons, evaluation of pump design features for satisfactory operation, safety and maintenance will vary with the particular process application.

On the next two pages you will find a general guide to the classification of pumps, Table VI, and a schedule of approximate head-capacity ranges, Table VII, as well as a selection of photos and drawings that illustrate typical centrifugal pumps and their parts. The turbine-type pump is a special centrifugal and it has limited, special-purpose applications.

Table VIII on p. 188 describes the basic parts of a centrifugal pump and the purpose each part serves.

Impellers Put Energy Into the Fluid

The impeller of a centrifugal pump imparts the main energy to the fluid for process applications. Fig. 28 shows three common varieties:

- Fully enclosed. Used for high-head, high-pressure applications.
- Semi-enclosed. Used for general-purpose applications. Has open vane tips at entrance to break up suspended particles and prevent clogging.
- Open. Used for low heads, suspended-solids applications, very small flows.

Radial vanes are usually provided on the back shroud or plate of the impeller to reduce the pressure on the stuffing box, and to prevent suspended solids from entering the back side and possibly causing clogging. Working, or pumping, vanes are "backward" in form relative to the rotation of the impeller.

Casing, Shaft, Bearings, Packing, Seals

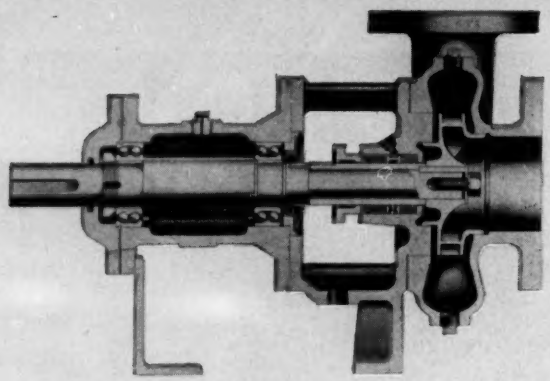
Pump casings may be fabricated from a wide variety of metals, as well as being lined to correspond to the material of construction selected for the impeller. Operating pressures go to about 5,000 psi. for forged or cast-steel barrel-type designs.

However, the usual process application is in the range of 75 to 800 psi., the latter being in light hydrocarbon processing and similar high-vapor-pressure systems.

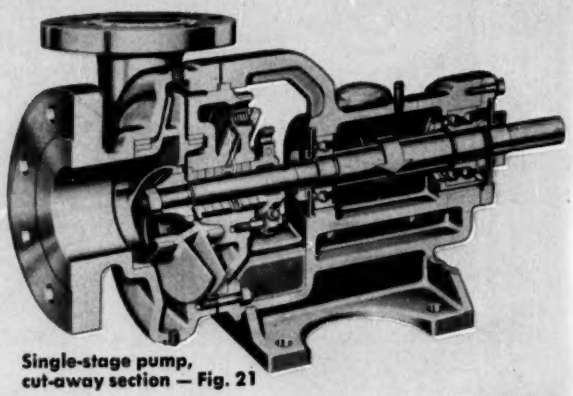
Removal of the casing parts is necessary for access to the impeller and often to the packing or seals. Some designs are conveniently arranged to allow dismantling the casing without removing the piping connections.

Proposed construction standards have been sug-

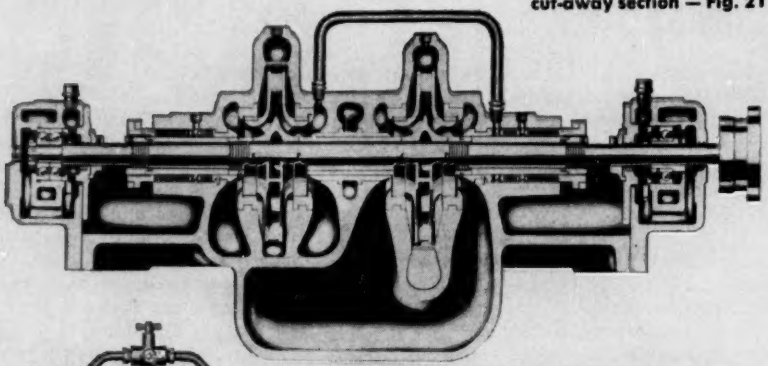
Here's a Quick Guide to Pump Classification and Selection, With Special



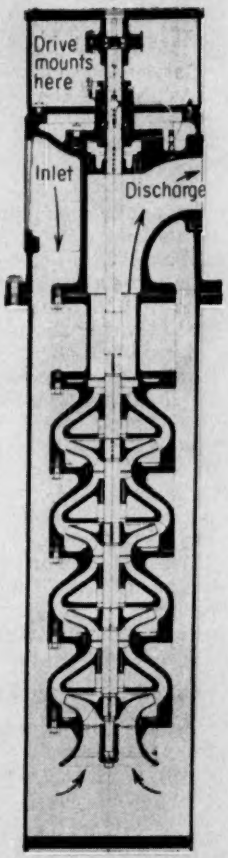
General chemical-service centrifugal — Fig. 20



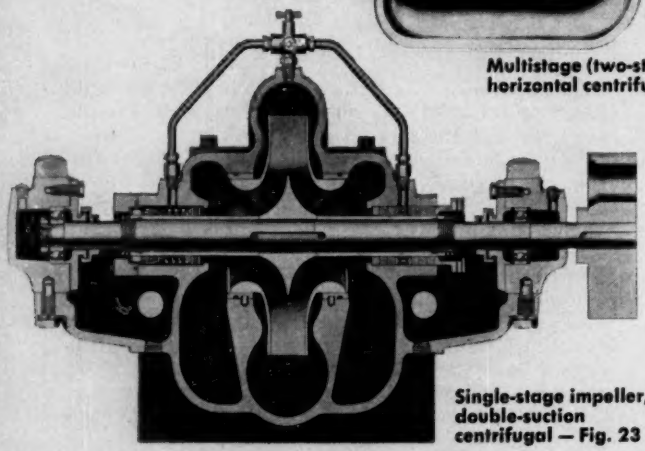
Single-stage pump, cut-away section — Fig. 21



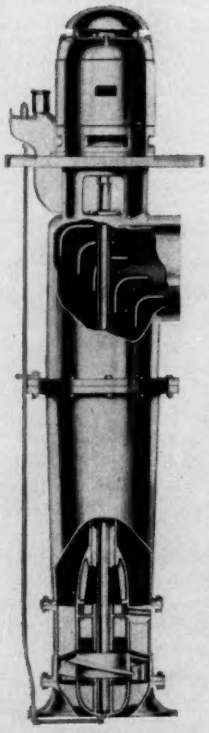
Multistage (two-stage in this case), horizontal centrifugal pump — Fig. 22



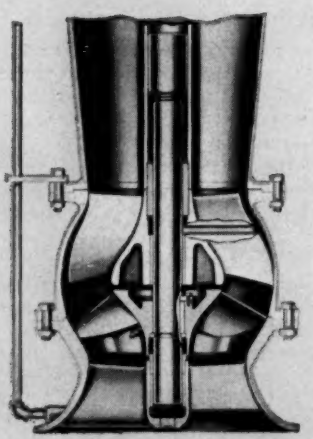
Vertical, multistage pump with barrel casing — Fig. 24



Single-stage impeller, double-suction centrifugal — Fig. 23

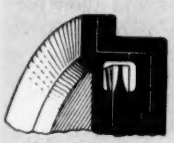


Single-stage, mixed flow, vertical inlet — Fig. 26

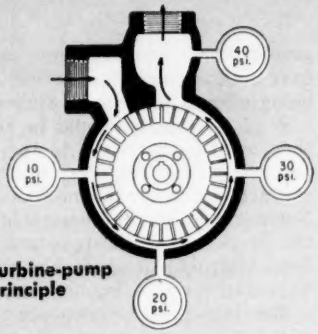


Vertical, propeller-type pump — Fig. 25

Emphasis on Those Centrifugals Offered for Particular Process Service



Cross-section of heads and impellers



Turbine-pump principle

Turbine-type pump — Fig. 27

General Classes of Pumps—Table VI

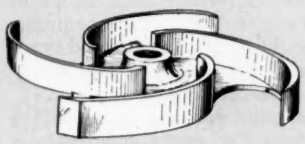
All available types will not be treated in detail here, but consideration of their particular design features is important in many situations.

Centrifugal	Rotary	Reciprocating
Centrifugal	Cam	Piston
Propeller	Screw	Plunger
Mixed-flow	Gear	Diaphragm
Peripheral	Vane	
Turbine	Lobe	

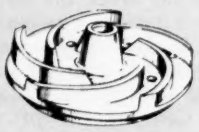
Approximate Head-Capacity Ranges For Centrifugal Pumps—Table VII

Class of Pump	Maximum* Capacity, Gpm.	Maximum* Head, Ft. of Fluid
Single-stage, horizontal	600	225
Double-suction, single-stage, horizontal	15,000	300
Multistage, horizontal	3,000	5,000
Single and multistage, vertical pumps		
a. Mixed-flow	100,000	75
b. Axial-flow	100,000	25

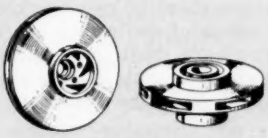
* Not necessarily at the same point.



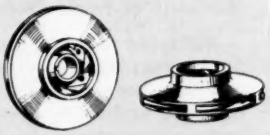
Four-vane, open-type impeller



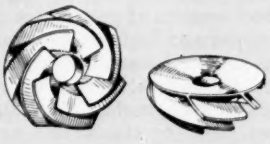
Semi-open



Enclosed, single-suction

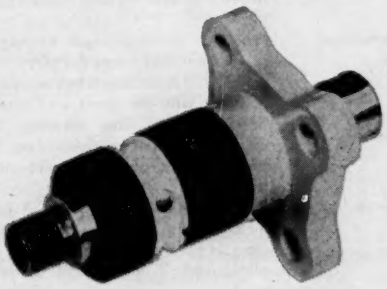


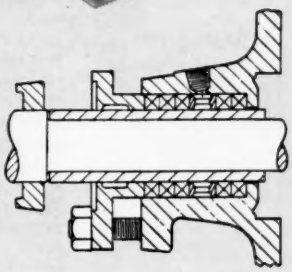
Enclosed, double-suction



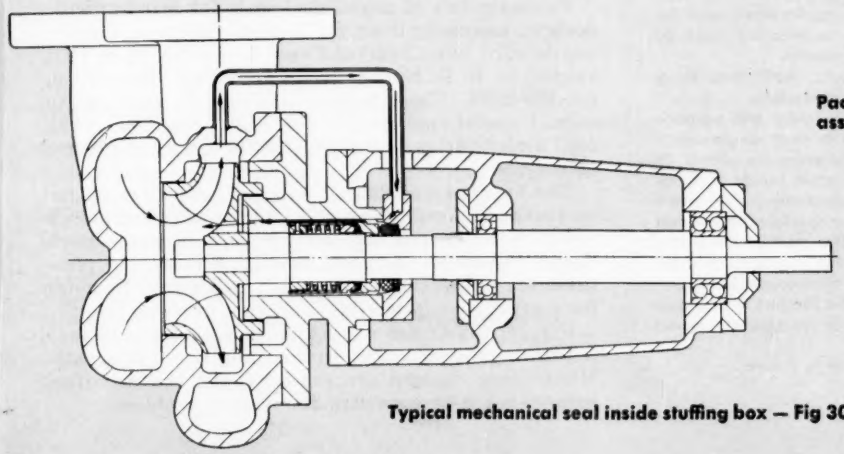
Mixed flow, semi-enclosed

Impeller types for centrifugal pumps — Fig. 28

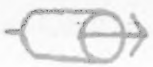




Packed stuffing box, assembled and cut-away — Fig. 29



Typical mechanical seal inside stuffing box — Fig 30



Centrifugal Pump Parts—Table VIII

Part	Purpose
Impeller	Impart velocity to the liquid, resulting from centrifugal force as the impeller is rotated.
Casing	To give direction to the flow from the impeller and to convert this velocity energy into pressure energy, usually measured in ft. of head.
Shaft	Transmits power from the driver to the impeller.
Stuffing box	This is a means of throttling the leakage which would otherwise occur at this point of entry of the shaft into the casing. Usually not a separate part, but rather made up of small details, as a. to d.
a. Packing	This is the most common means of throttling the leakage between the inside and outside of the casing.
b. Gland	To position and adjust the packing pressure.
c. Seal cage (also called water seal or lantern ring)	Provides passage to distribute the sealing medium uniformly around the portion of the shaft that passes through the stuffing box. This is very essential when suction lift conditions prevail to seal against in-leakage of air.
d. Mechanical seal	Provides a mechanical sealing arrangement that takes the place of the packing. Basically, it has one surface rotating with the shaft and one stationary face. The minutely close clearance between these two faces prevents leakage of liquid out or air in.
Shaft sleeve	To protect the shaft where it passes through the stuffing box. Usually used in pumps with packing but often eliminated if mechanical seals are used.
Wearing rings	To keep internal recirculation down to a minimum. Having these rings as replaceable wearing surfaces permits renewal of clearances to keep pump efficiencies high. On small types only one ring is used in the casing; on larger sizes companion rings are used in the casing and on the impeller.
Wearing plates	With open-type impellers or end-clearance wearing fits these serve the same purpose as wearing rings do with radial clearances.
Bearings	Accurately locate shaft and carry radial and thrust loads.
Frame	Mounts the unit rigidly and supports the bearings. In most single-suction pumps this is a separate piece. In many double-suction pumps the support is through feet cast as part of the casing. In some special suction pumps the feet are also part of the casing and the bearing assembly is overhung. With close-coupled, single-suction types this support is provided by the motor or by special support adapters.
Coupling	To connect pump to driver.

gested. When adopted, these standards would allow for easy maintenance of many of the types of pumps now being offered for sale in a nonstandard fashion.

Shaft materials should be selected with care, since they must be resistant to the corrosive action of the process fluids. Yet, they must possess good strength characteristics for the mechanical design requirements. For some designs it's desirable to use a shaft sleeve of the proper corrosion-resistant material over the preferred structural shaft material. These sleeves may be metal, ceramic, rubber, etc.

Bearings must be adequate to handle the shaft loads without excessive wear, assuming lubrication is maintained. Usually this is not a point of real question, provided the manufacturer has had experience with the kind of loads imposed by chemical service conditions. In any event, the responsibility for adequate design of bearings must rest with the manufacturer of the pump.

In all cases bearings should be of the outboard type; that is, not in the process fluid, unless special conditions make this situation unacceptable.

Conventional soft or metallic packing in a stuffing box, Fig. 29, is satisfactory for many low-pressure, noncorrosive-fluid systems. Special packings, or mechanical seals, are in common use for corrosive fluids.

Mechanical Seals Need Special Care

When the pressure goes above about 50 psig., or the fluid is corrosive, additional means of sealing the shaft must be provided. Particular care must be used in handling and using these mechanical seals and special instructions should be obtained from the seal manufacturer.

Generally speaking, it is not wise to have the mechanical seals installed at the pump factory, as the slightest amount of grit on the faces can cause permanent damage or destruction after only one or two revolutions at pump speed. Seals should be inspected and cleaned immediately prior to initial startup.

The "single" mechanical seal is made of a rotating element fixed to the shaft (or shaft sleeve), and a stationary element fixed to the pump casing.[35] The "double" seal is for severe sealing (corrosion or abrasion). Sealing faces between the elements are in a plane normal to the shaft, and have low coefficients of friction to allow very close contact with low wear. The internal seal fits inside the stuffing box while the external seal is outside.

Fundamentals of mechanical seals for many specific designs, especially those for handling abrasive liquids, are detailed in a *Chemical Engineering* Report on that subject by R. D. Norton (see *Chem. Eng.*, Sept. 1956, pp. 199-210). These various designs are attempts to correct operational problems or seal weaknesses when used under various conditions in the chemical process industries.

The average unbalanced external seal is good for pressures of about 30 psig., while the balanced design will handle 150 psig. Special designs will handle much higher pressures. Actually, maximum operating pressures are a function of the shaft speed and diameter for a given seal design fluid and fluid temperature.

Fig. 30 illustrates a mechanical seal installed in a conventional stuffing box with cooling liquid flow path. Many other designs are available and the manufacturers should be consulted for specific problems.

How to Select a Centrifugal Pump

The centrifugal pump is a versatile unit in the process plant. It offers a central source of nonpulsing flow at a predetermined limited pressure. It can be operated to satisfy the requirements of many small and large flow systems.

Generally speaking, the centrifugal pump has these characteristics:

- Wide range of capacity, pressure and fluid operating conditions.
- Easily adapted to direct motor, V-belt or other drive.
- Requires a relatively small floor area.
- Relatively low cost.
- Difficult to obtain very low flows at moderate to high pressures.
- Develops turbulence in fluids handled.

The turbine-type centrifugal offers these operating and design characteristics: high heads at low flows; self-priming; limited to very clean, nonabrasive fluids with limited physical properties; clearances can be a problem on assembly, and for maintenance.

Fig. 31 indicates the relative performance for three kinds of centrifugal pumps, with the curves labeled "centrifugal" referring to the usual process (open- or closed-impeller) unit. A similar set of curves is shown in Fig. 32 for the turbine unit. Note that the flat head curve of the centrifugal has advantages for many process systems, giving fairly constant head over a wide range of flow.

For some systems where changes in flow must be reflected by pressure changes, the turbine characteristics are preferred. The centrifugal impeller provides an ever-rising horsepower requirement with increasing flow, while the horsepower of the turbine pump falls off with increasing flow (and decreasing head); hence the turbine pump is overloaded at low flows and must be operated with ample horsepower for these conditions.

Effect of impeller shape on performance of the usual centrifugal pump is shown in Fig. 33. The only part the process designer can play is in the selection of a manufacturer's performance curve to fit the control requirements of the system.

If the curve is too steep, he can suggest an impeller with the necessary basic characteristics to move the curve in the proper direction—if the manufacturer has an impeller pattern to fit that pump casing, and with

Horizontal vs. Vertical—Table IX

Feature	Horizontal Pump	Vertical Pump
Space required	Less headroom.	Less floor area, more headroom.
NPSH	Requires more.	Requires less.
Priming	Required for some conditions.	Usually not required.
Flexibility for future changes	Less.	More.
Maintenance	More accessible.	Major work project.
Corrosion and abrasion	No great problem.	Can be a considerable problem.
Cost	Less.	More. More alloy needed for corrosive fluids.

Based on Liquid Handled—Table X

Liquid	Basic Pump Type	Impeller
Water, other clear noncorrosive liquids at cold or moderate temperatures	Single or double suction.	Closed except for very small capacities.
Water above 250F.	Single or double suction. Usually boiler feed service at high pressures requiring multistage pumps.	Closed except for very small capacities.
Hydrocarbons, hot	Single suction, often of the special type called refinery pumps, designed for particularly high-temperatures.	Closed with large inlets.
Corrosives		
Mildly acid or alkaline	Single or double suction.	Closed except for very small capacities or where liquid tends to form scale on surfaces of moving parts.
Strongly acid or alkaline	Single or double suction with single suction probably less expensive if available for the rating.	
Hot corrosives	Single suction, with many refinery pumps also used here because of high temperatures and corresponding suction pressures.	
Water With Solids in Suspension		
Fine abrasives	Single suction with end clearance wearing fits. If all particles pass through 1/8-in. mesh, rubber-lined pumps available which give many times the life of metal pumps, if no chemical actions or excessive temperatures to harm rubber.	Open, which allows better application of the rubber, except in larger sizes Also made in the closed type.
Coarse abrasives	Single suction. Not available for full range of ratings. Small capacities not obtained easily.	Closed.
Pulpy solids such as paper stock.	Single suction. Double suction only used on very low solids concentrations, and then with special end-clearance wearing fits.	Closed. Open type used to be standard, but change to end-clearance wearing fits made closed impeller more suited.

the improved physical dimensions. This may require changing the make of the pump to obtain the necessary range and characteristics. The process designer would then, of necessity, specify by name of manufacturer and model number.

For conditions of high suction-side friction loss or low available net positive suction head (NPSH) of 10 ft. or less, a large open eye on the impeller is necessary to keep the inlet velocity low. The manufacturer should be given the process conditions in order to appraise this situation properly.

In most instances the manufacturer has a series of impellers to be used in one standard casing size. The impeller may be trimmed to proper diameter to meet head requirements and yet stay within the power range of a specified pump driver.

Note that it is not necessary to put a full-size impeller in a casing unless the system requires this performance. It is useful to know when larger impellers can be placed inside the casing, and what their anticipated performance might be. This will help the process design engineer and operating personnel to plan for future uses and changing loads on the pump.

Multistage Pump Used for Higher Flows

Although the discussion above has been limited to single impellers, the principles are the same for multistage centrifugal pumps (impellers in series in the pump casing) and the casing with double inlets. The latter pump is used for higher flows, usually above 500 gpm., and this design serves to balance the inlet load as it enters the impeller or first stage (if more than one) from two sides instead of one as in the single impeller.

The double suction pump has the liquid passages as a part of the casing, with still only one external suction piping connection.

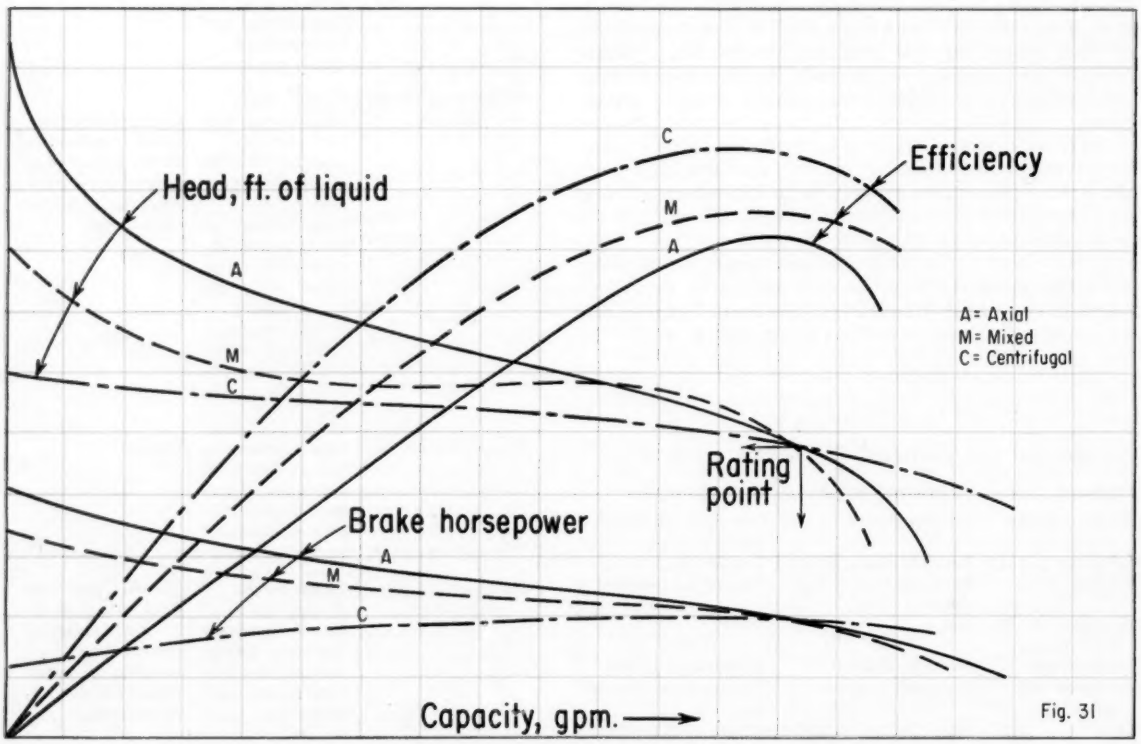
Axial- and mixed-flow impellers are used primarily for very high capacities at relatively low heads. They are usually applied to services such as intake water to a system, waste water disposal, recirculating large process liquor flows, and the like. Table VII on p. 187 gives some comparative figures.

Many process applications can be handled either by a horizontal or a vertical pump. In the range usually associated with process plants and their utility services the guides outlined in Ref. 35 are helpful in making the selection. Table IX on p. 189 summarizes some of the design information given in Ref. 35.

When You Use Pumps in Series

Sometimes it's advantageous or economical to use two or more centrifugal pumps in series in order to reach the desired discharge pressure.

In this situation the capacity is limited by the smaller capacity of any one of the pumps (if they are different) at its speed of operation; and the total discharge pressure of the last pump in the series is the



RELATIVE PERFORMANCE curves for axial-flow, mixed-flow and centrifugal pumps.

sum of the individual discharge pressures of the individual pumps.

For identical pumps, the capacity is that of one pump; and the discharge pressure of the last pump is the sum of the individual heads of each pump acting as a single unit. For example, for two identical pumps the discharge head is twice that of the rated pressure of one pump at the designated flow rate.

When designing for pumps in series note, however, that the pump casing of each stage—particularly the last—must be of sufficient pressure rating to withstand the total developed pressure.

When You Hook Up Pumps in Parallel

Pumps are operated in parallel to divide the load between two, or more, smaller pumps rather than a single large one; or to provide additional capacity in a system on short notice; or for related reasons.

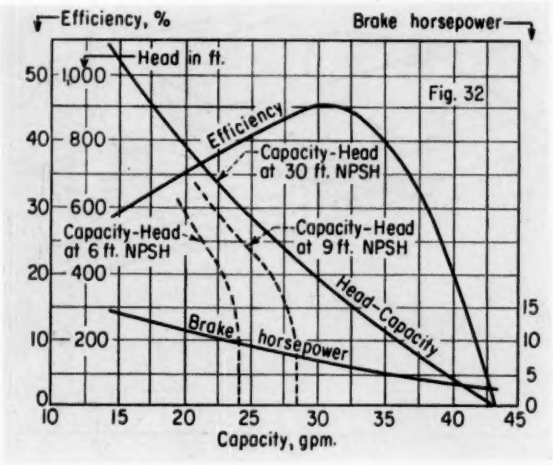
Fig. 34 shows the operation curve of two identical pumps hooked up in parallel, each pump handling one half the total capacity at the system head conditions. In the parallel arrangement of two or more pumps of the same or different characteristic curves, the capacities of all the pumps are added together—at the head of the system—to obtain the resulting delivery flow.

Each pump does not have to carry the same flow; but it will operate on its own characteristic curve, and must deliver the required head. At the common tie point on the discharge of all the pumps, the head will be the same for each pump regardless of its flow.

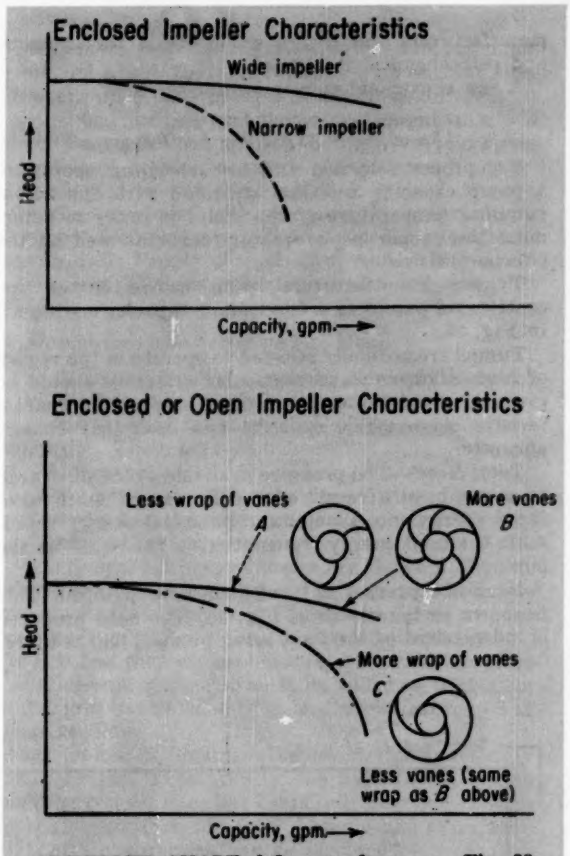
Characteristic curves for each of the pumps must be continuously rising as shown for the single pump of Fig. 34, otherwise with drooping or looped curves there may be two flow conditions for any one head, and the pumps would "hunt" back and forth with no way of becoming stabilized.

Typical Hydraulic Characteristics

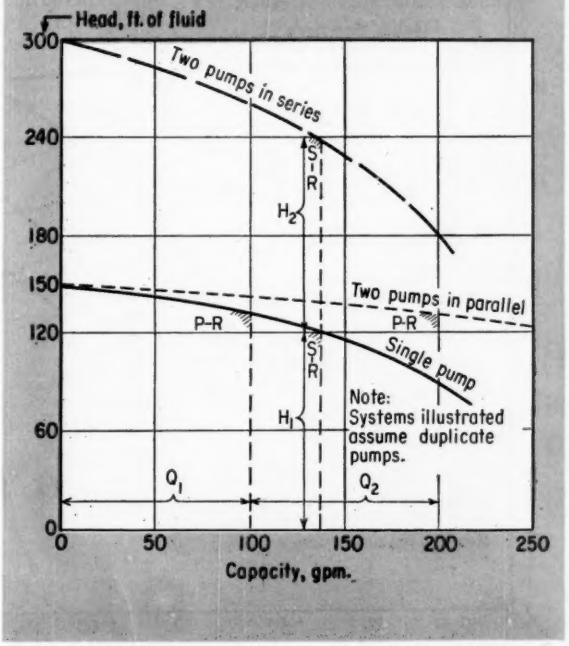
Capacity is the rate of liquid or slurry flow through a pump. This is usually expressed as gpm. by pump



TYPICAL PERFORMANCE of turbine-type pumps.



IMPELLER SHAPE defines performance—Fig. 33



PARALLEL, SERIES performance curves—Fig. 34

manufacturers and design engineers in the chemical and petrochemical industries.

A few convenient conversion factors are:

1 Imperial gal./min. = 1.201 gpm.
1 barrel/day = 42 gal./day = 0.0292 gpm.

For proper selection and corresponding operation, a pump capacity must be identified with the actual pumping temperature of the liquid in order to determine the proper power requirements as well as the effects of viscosity.

Typical manufacturers' performance curves for centrifugal pumps as a function of capacity are shown in Fig. 35.

Pumps are normally selected to operate in the region of high efficiency; and particular attention should be given to avoid the extreme right side of the characteristic curve where capacity and head may change abruptly.

Total Head—The pressure available at the discharge of a pump as a result of the change of mechanical input energy into kinetic and potential energy represents the total energy transmitted to the liquid by the pump.

Head is expressed as ft. of fluid being pumped. This is shown on the curves of Fig. 35. The head produced is independent of the fluid being pumped and is therefore the same for any fluid through the pump at a given speed of rotation and capacity.

Head may be expressed in units other than ft. of fluid by conversions that take the specific gravity of the fluid into account.

1 psi. = 2.31 ft. of water at Sp. Gr. = 1.0
1 psi. = 2.31 ft. of water/Sp. Gr. of liquid
Ft. of water/Sp. Gr. of liquid = ft. of liquid
1 in. Hg = 1.134 ft. of water
1 in. Hg = 1.134/Sp. Gr. of liquid, as ft. of liquid

For water Sp. Gr. = 1.0 at 62 F., although for general use it can be considered to be equal to 1.0 over a wide range of temperatures.

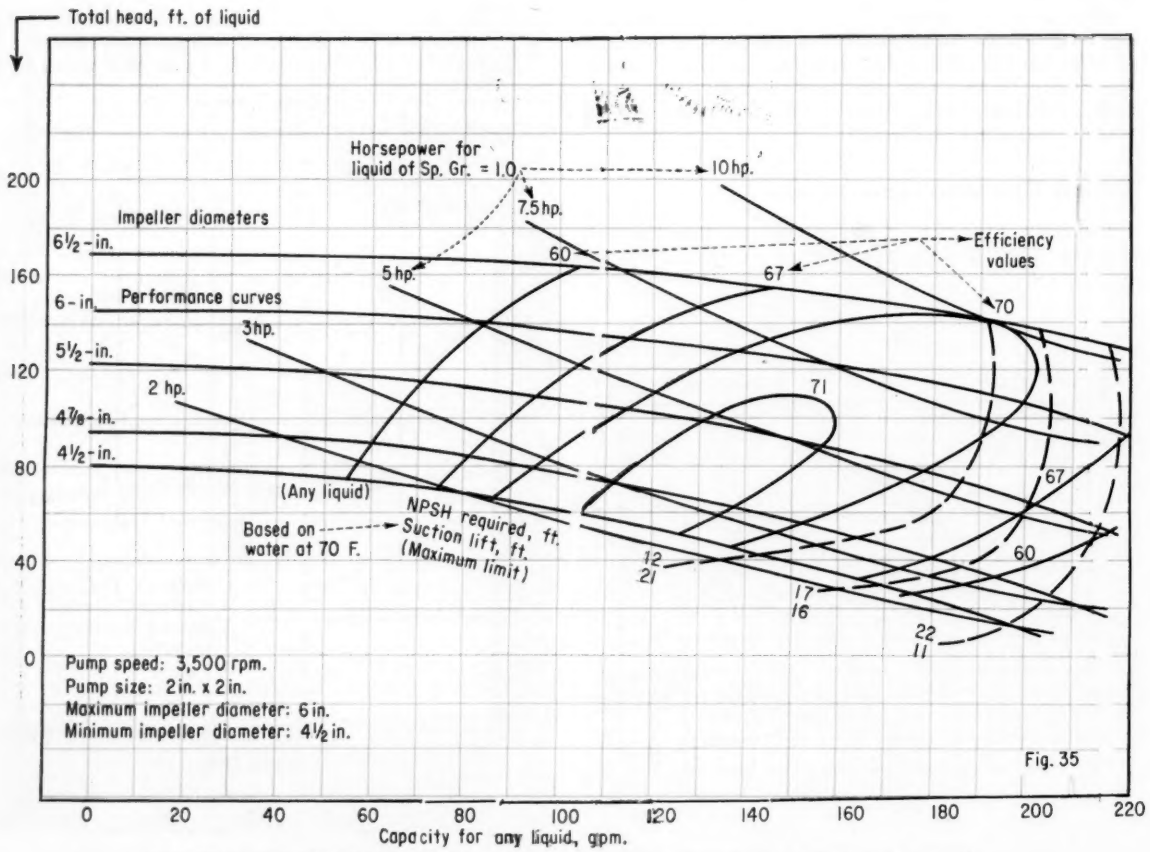
How to Figure Feet of Fluid Head

Problem 1—If a pump is required to deliver 50 psig. to a system, how many ft. of head would this be equivalent to?

Solution—For water, the ft. of head on the pump curve must read 2.31(50) = 115.5 ft. For a liquid of Sp. Gr. = 1.3, the ft. of head on the pump curve must read 115.5/1.3 = 88.8 ft. of fluid.

For liquid of Sp. Gr. = 0.86, the ft. of head on the pump curve must read 115.5/0.86 = 134.2 ft. of liquid.

If a pump were initially selected to handle a liquid



TYPICAL PERFORMANCE CURVES for centrifugal pumps as a function of capacity.

of Sp. Gr. = 1.3 at 88.8 ft., a substitution of light hydrocarbon of Sp. Gr. = 0.86 would mean that the head of liquid developed by the pump would still be 88.8 ft., but the pressure of this lighter fluid would only be:

$$88.8/[(2.31)/(0.86)] = 44.8 \text{ psi.}$$

Note that for such a change in service, the impeller seal rings, packing (or mechanical seal) and pressure rating of casing must be evaluated to ensure proper operation with a volatile fluid.

The total head developed by a pump is composed of the difference between the static pressure and velocity heads plus the entrance and exit and pipe friction losses for the suction and discharge sides of pump. Referring to Figs. 36 and 37,

$$H = h_D - h_S$$

When a suction lift is involved, the sign of h_D is negative, making

$$H = h_D - (-h_S) = h_D + h_S$$

To Get Suction Head or Suction Lift

Total suction head, Fig. 38, is the difference in elevation between the liquid on the pump suction side and the centerline of the pump (plus the velocity head), noting that the suction head is positive when above the pump centerline, and that it is decreased with an increase in friction losses through the suction piping system. Thus,

Total Suction head = Static head − friction losses

Total suction lift is defined as above, except the level of the liquid is below the centerline of the pump; or the value is below atmospheric pressure. Its sign is negative when gage pressure is used as a base.

Total suction lift = Static lift + friction losses

For general service the average centrifugal pump should lift about 15 ft. of water on its suction side. However, since each process situation is different, it is not sufficient to assume that a particular pump will deliver the needed suction lift. Actually, certain styles or models of a manufacturer's pumps are often specially adapted to high-lift conditions.

On the other hand, it's unnecessary to select a high-lift pump when pressure head or flooded suction conditions prevail. Proper evaluation of suction lift conditions cannot be overemphasized.

To Determine the Discharge Head

The discharge head of a pump is the head measured at the discharge nozzle, but referenced to centerline, and is composed of the same basic factors summarized previously. These are:

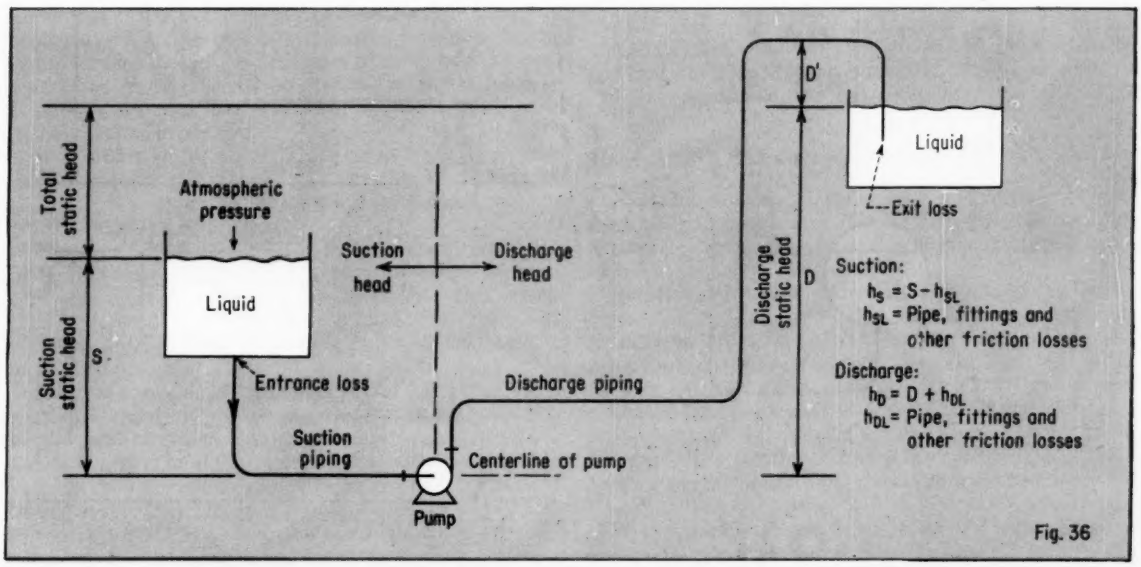
1. Static head.
2. Friction losses through pipe, fittings, contractions, expansions, entrances and exits.
3. Terminal system pressure.

Some typical discharge systems are shown in Fig. 39. General practice is to express the terminal discharge pressure P at a vessel, as in Fig. 39a, in terms of gage pressure. Hence, $P = 0$ for atmospheric discharge.

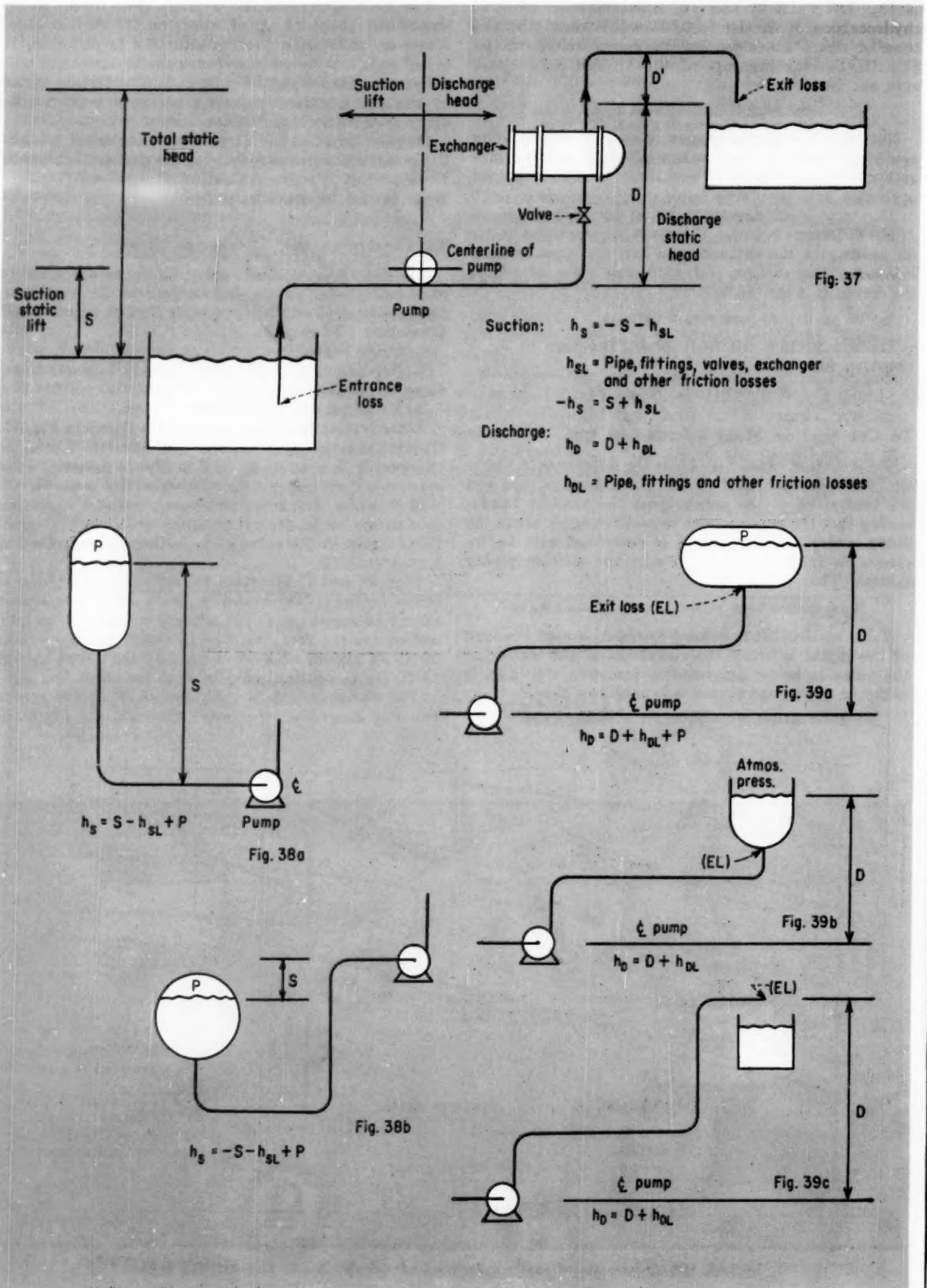
If P is less than atmospheric or otherwise expressed in absolute units, then it must be added as equivalent ft. of liquid to the value of h_D ordinarily expressed as a gage reading.

Figs. 36 and 37 illustrate the use of siphon action in pump systems. Theoretically, the head in the siphon should be recoverable; but actually it may not, at least not equivalent foot for foot. Usually not more than 20 ft. of siphon action can be included[25] even though 34 ft. are theoretically available at sea level.

The siphon length is indicated as D' in the accompanying diagrams. For some systems, the discharge



TOTAL HEAD consists of static pressure and velocity heads plus friction losses.


Suction lift
Discharge head
Total static head
Exchanger
D'
Exit loss
D
Valve
Discharge static head
Centerline of pump
Suction static lift
S
Pump
Entrance loss
Fig. 37
Suction: $h_s = -S - h_{SL}$
h_{SL} = Pipe, fittings, valves, exchanger and other friction losses
$-h_s = S + h_{SL}$
Discharge: $h_D = D + h_{DL}$
h_{DL} = Pipe, fittings and other friction losses
P
S
℄
$h_s = S - h_{SL} + P$
Pump
Fig. 38a
P
Exit loss (EL)
D
℄ pump
Fig. 39a
$h_D = D + h_{DL} + P$
Atmos. press.
(EL)
D
℄ pump
Fig. 39b
$h_D = D + h_{DL}$
P
S
Fig. 38b
$h_s = -S - h_{SL} + P$
(EL)
D
℄ pump
Fig. 39c
$h_D = D + h_{DL}$

head on the pump should be considered to be $D + D'$, neglecting the siphon action. In any case, if air can be trapped in the loop—and it usually can—it must be vented during startup. Otherwise the pump will be working against the head established using $D + D'$.

On startup the flow can be gradually increased, making more head available from the pump to overcome the higher starting head of the system. This should not be overlooked nor underestimated in determining design specifications for the pump.

Velocity Head and Friction

Velocity head of the flowing fluid is expressed as follows:

$$h_v = v^2/2g, \text{ ft. of fluid}$$

As a component of both suction and discharge heads, velocity head is determined at the pump suction or discharge flanges respectively, and added to the *gage* reading. The actual pressure head at any point is the sum of the gage reading plus the velocity head. The velocity head cannot be read from the gage since it is a kinetic energy function as contrasted with the measured potential energy. The values are usually, but not always, negligible.

Present design practice is for these velocity head effects at the pump suction and discharge connections to be included in the pump performance curve and pump design. Therefore, they need not be actually added to the heads calculated external to the pump itself.[29]

The friction losses for fluid flow in pipe, valves and fittings are determined as presented in the first section of this report (pp. 161-184). Entrance and exit losses must be considered in these determinations, but are not to be determined for the pump entrance or discharge connections into the casing.

NPSH and Pump Suction

Net positive suction head (NPSH) in ft. of liquid above the vapor pressure of the liquid at the pumping temperature is the absolute pressure available at the pump suction flange. NPSH is a very important consideration in selecting a pump that might be able to handle liquids at or near their boiling points, or liquids of high vapor pressures.

If this consideration of NPSH is ignored, the pump may well be inoperative in the system; or it may be on the border line and be a very troublesome and expensive piece of equipment.

The significance of NPSH is to ensure sufficient head of liquid at the entrance of the pump impeller to overcome the internal flow losses of the pump. This allows the pump impeller to operate with a full "bite" of liquid essentially free of flashing bubbles of vapor due to boiling action of the fluid.

For low available NPSH (less than 10 ft.) the pump suction connection and impeller eye may be considerably oversized when compared with a pump not required to handle fluid under these conditions. Poor suction conditions due to inadequate available NPSH is one major contribution to cavitation in pump impellers; and this is a condition at which the pump cannot operate for very long without physical erosion damage to the impeller.

The NPSH *available* from or in the liquid system on the suction side of the pump is expressed as:

$$\text{NPSH} = S + (p_s' - p_{vp}') - h_{SL}$$
$$\text{NPSH} = S + (P_s - P_{vp})\ (2.31/\text{Sp. Gr.}) - h_{SL}$$

where p_s' or P_s represent the absolute pressure in the vessel (or atmospheric) on the liquid surface on the suction side of the pump; p_{vp}' or P_{vp} represent the absolute vapor pressure of the liquid at the pumping temperature; h_{SL} is the suction line, valve, fitting and other friction losses from the suction vessel to the pump suction flange; and S may be positive or negative depending on whether static head or static lift is involved in the system.

This *available* value of NPSH (of the system) must always be greater by a minimum of 1 ft., and preferably 2 ft. or more, than the *required* NPSH stated by the pump manufacturer or shown on the pump curves. *NPSH required by the pump* is a function of the physical dimensions of the casing, speed and type of impeller. This required NPSH must be satisfied for proper pump performance.

The pump manufacturer should always be given complete suction conditions if he is to be expected to recommend a pump to give long and trouble-free service. Required NPSH of a pump at a given capacity-head rating increases as the pump speed increases:

$$\text{Rpm. varies as } (\text{NPSH})^{0.75}$$

For this reason, many critical-suction-condition installations use relatively slow-speed pumps.

As the altitude of the installation increases above sea level, the barometric pressure, and hence p_s' or P_s decreases for any open-vessel condition. This decreases the available NPSH.

Fig. 35 represents a typical manufacturer's performance curve. The values of NPSH given are the minimum values required at the pump suction. As mentioned before, good practice requires that the NPSH available be at least 2 ft. of liquid above these minimum values.

It's important to recognize that the NPSH and suction lift values are for handling water at about 70 F. To use with other liquids it is necessary to convert to the equivalent water suction lift at 70 F. and sea level.

Total suction lift (as water at 70 F.) is equal to NPSH (calculated for the fluid system) less 33 ft.

How NPSH Enters Design Problems

Problem 2—What is the suction lift value to be used with the pump curves of Fig. 35, if a gasoline pumping system is calculated as having 15 ft. of NPSH *available?*

Solution—Total suction lift calculated as water equals $15 - 33 = -18$ ft. Therefore a pump must be selected which has a lift of at least 18 ft. The pump described by the performance curve in Fig. 35 is satisfactory using an interpolated suction lift line between the dotted curves for 16 ft. and 21 ft. of water.

Performance of the pump will be satisfactory in the region to the left of the new interpolated 18-ft. line. Proper performance should not be expected near the line, however.

If the previous system were at sea level, consider the same pump with the same system at an altitude of 6,000 ft. Here the barometric pressure is 27.4 ft. of

water. This is 34 − 27.4 = 6.6 ft. less than the sea-level installation.

The new NPSH will be 15 − 6.6 = 8.4 ft. *available.* Referring to the pump curve of Fig. 35, it's apparent that this pump cannot do better than 21 ft. suction lift as water or 12 ft. NPSH of fluid.

Total suction lift as water = 8.4 − 33 = 24.6 ft. The pump curves show that 21 ft. suction lift of water is all the pump can do. Thus, 24.6 ft. is too great. A different pump must be selected to handle this high value of suction lift.

Such a pump may be expensive, and the process design engineer may decide to use a positive displacement pump for this particular service. Normally, lifts are not considered to be reasonable if they are over 20 ft.

Problem 3—Let's calculate the NPSH available in an open-vessel system at sea level. Fig. 36 diagrams such a system. Conditions: At sea level, P_a = 1 atm. or 14.7 psia. Assume the fluid in the system is water at 85 F. with a vapor pressure P_{vp} = 0.6 psia.

Assume also that the tank liquid level is 10 ft. above the centerline of the pump. Then S = +10 ft. Assume that friction losses have been calculated to be 1.5 ft., h_{SL} = 1.5.

Solution—Given the information above, we can now calculate available NPSH:

$$\text{NPSH} = S + (P_a - P_{vp})(2.31/\text{Sp. Gr.}) - h_{SL}$$
$$\text{NPSH} = 10 + (14.7 - 0.6)(2.31/0.997) - 1.5 = 41.2 \text{ ft.}$$

Problem 4—Now, let's calculate the NPSH in an open vessel that is not at sea level.

Conditions: The vessel is at an altitude of 1,500 ft., where atmospheric pressure is 13.92 psia. Therefore, P_a = 13.92. The liquid in the vessel is water at 150 F., whose vapor pressure P_{vp} = 3.718 psia.; and the Sp. Gr. = 0.982.

Assume the vessel liquid is 12 ft. below the centerline of the pump, S = −12 ft.

For friction losses, assume that they have been calculated as 1.1 ft. of liquid.

Solution—We now have enough design information to determine the NPSH available:

$$\text{NPSH available} = S + (P_a - P_{vp})(2.31/\text{Sp. Gr.}) - h_{SL}$$
$$= -12 + (13.92 - 3.718)(2.31/0.982) - 1.1$$
$$\text{NPSH available} = 10.88 \text{ ft.}$$

Available NPSH in a Vacuum System

Problem 5—What is the NPSH available in a vacuum system such as that shown in Fig. 38a?

Conditions: The vessel is a liquid collector operating at 28 in. of Hg vacuum, referred to a 30 in. of Hg barometer. This is 30 − 28 = 2 in. of Hg abs., or P_a = (14.7/30) (2) = 0.98 psia.

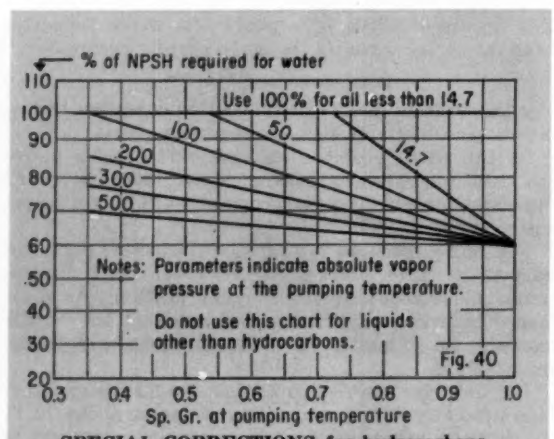
The liquid collected is water at 101.2 F. with a vapor pressure of 0.98 psia.

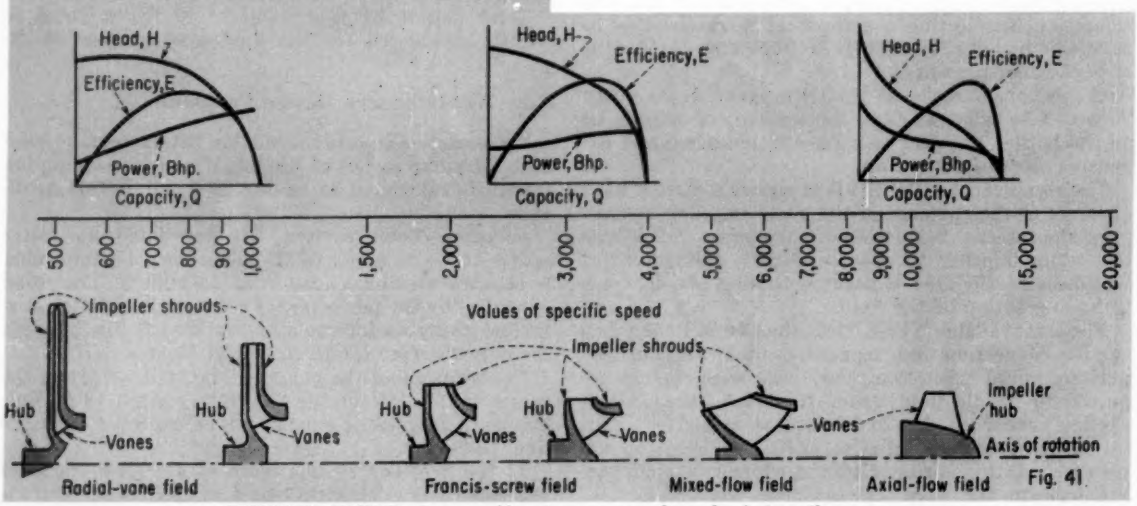
Assume that the liquid level in the vessel is 5 ft. above the centerline of the pump. For the friction losses, assume a value of 0.3 ft. of liquid.

Solution—This problem is solved in the same way as the problems above.

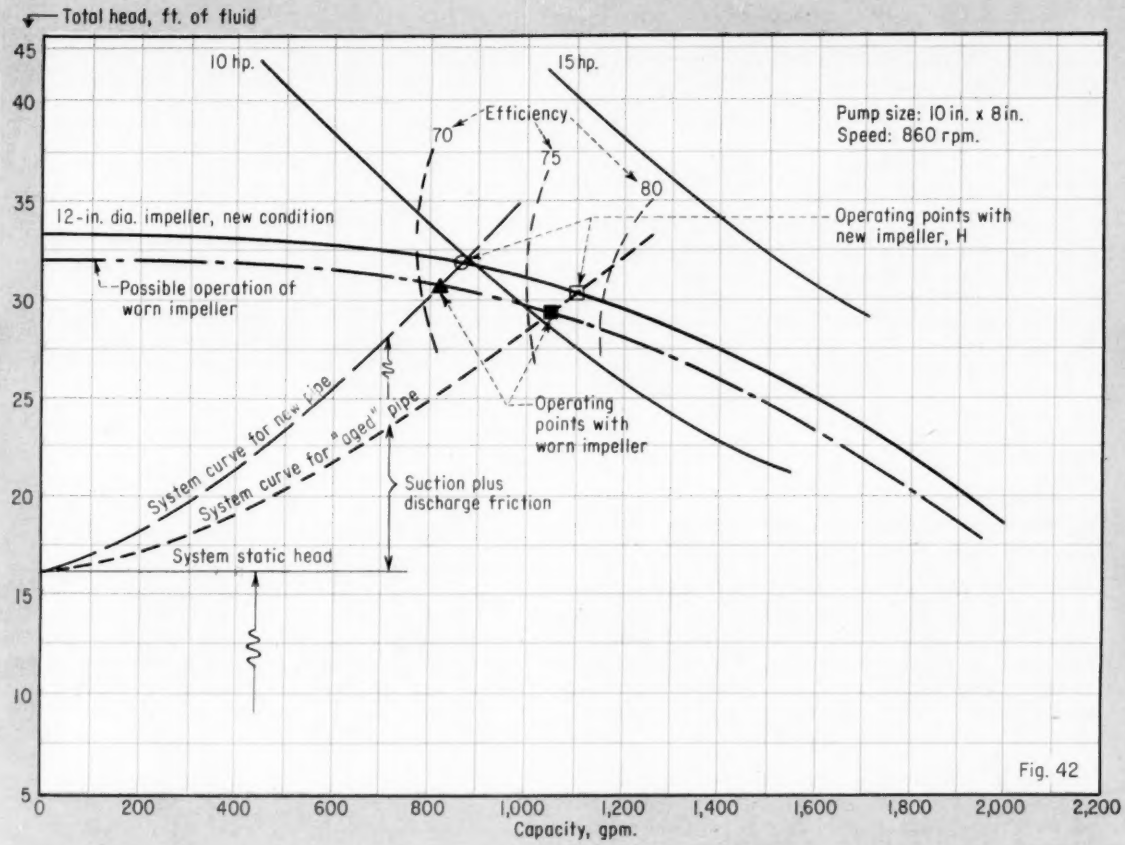
$$\text{NPSH available} = S + (P_a - P_{vp})(2.31/\text{Sp. Gr.}) - h_{SL}$$
$$= 5 + (0.98 - 0.98)(2.31/0.994) - 0.3$$
$$\text{NPSH available} = 5 - 0.3 = 4.7 \text{ ft.}$$

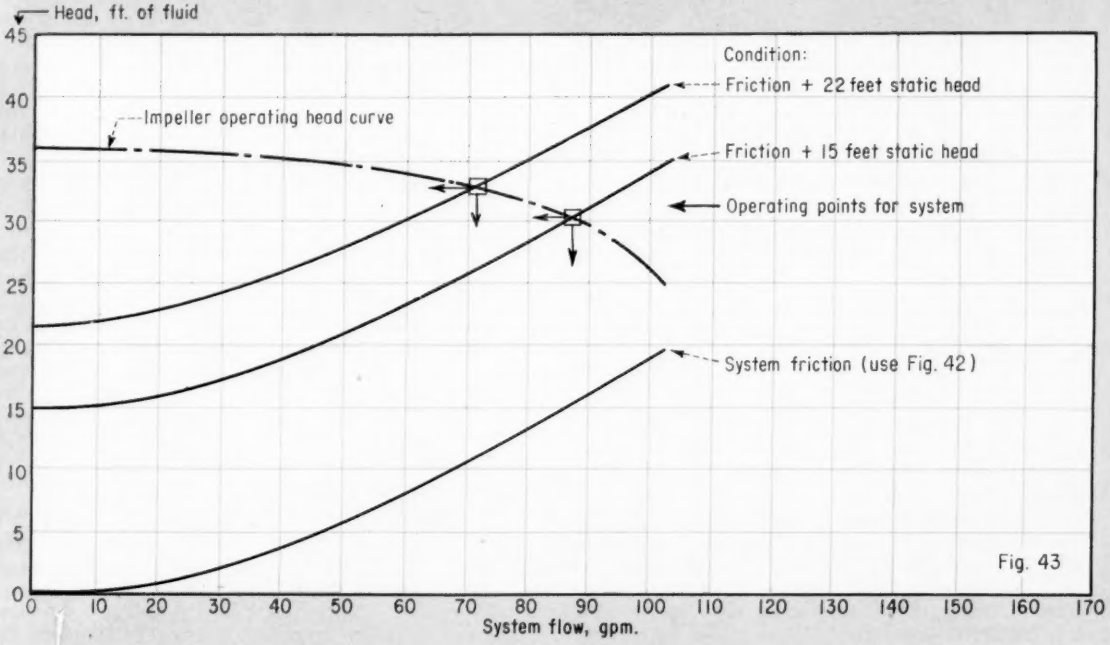
The pump selected for this application (water boiling





SPECIFIC SPEED of a centrifugal pump correlates basic impeller types.





THE DESIGNER should examine the system as it is intended to operate.

at 0.98 psia.) must have a required NPSH less than 4.7 ft., preferably about 3 to 3.5 ft.

This design specification is very difficult to meet. If possible, the vessel should be elevated to make more head, S, available. This will in turn raise the value of available NPSH.

NPSH Available in a Pressure System

Problem 6—Calculate the NPSH available in the pressure system shown in Fig. 38b. Conditions: Vessel contains butane at 90 F. and 60 psia. system pressure. This means that $P_s = 60$.

Butane vapor pressure, P_{vp} at 90 F. = 44 psia.; and Sp. Gr. = 0.58.

Assume the liquid level to be 8 ft. below the pump centerline, $S = -8$ ft. Assume the friction losses to be 12 ft. of liquid.

Solution—Proceeding as we have done previously:

$$\text{NPSH available} = S + (P_s - P_{vp})(2.31/\text{Sp. Gr.}) - h_{SL}$$
$$= -8 + (60 - 44)(2.31/0.58) - 12$$
$$\text{NPSH available} = 43.8 \text{ ft.}$$

This presents no pumping problem.

Special Corrections for Hydrocarbons

For hydrocarbons, the Hydraulic Institute[35] recommends the use of a correction multiplier to account for the difference in specific gravity. Fig. 40 is a chart of recommended multipliers. This indicates that the required NPSH as given on the pump performance curves may be reduced for conditions within the range of the curve.

For example if the pump whose performance curve is shown in Fig. 35 were being used to pump butane at 90 F. and 0.58 gravity, the correction multiplier from the Hydraulic Institute NPSH curve is about 0.99 by interpolation.

This means that the values obtained from Fig. 35 should be multiplied by 0.99 to obtain the actual NPSH the pump would require when handling a *hydrocarbon* under these conditions. Note that the correction does not apply to fluids other than hydrocarbons.

If the system pressure were 46 psia., then,

$$\text{NPSH available} = -8 + (46 - 44)(2.31/0.58) - 12$$
$$\text{NPSH available} = -12 \text{ ft.}$$

This is an impossible and unacceptable design condition. It means that the liquid will flash in the line and in the impeller, and cannot be pumped. NPSH must *always* be positive in sign.

Specific Speed Correlates Basic Types

The specific speed of a centrifugal pump correlates the basic impeller types shown in Fig. 41. The formula for specific speed is:

$$N_s = (n)(Q)^{0.5}/H^{0.75}$$

where Q is the capacity in gpm. at speed n and head H; speed is given in rpm.; and H is the total head per stage in ft. of fluid.

Principal significance of specific speed for the process engineer is to evaluate the expected performance of a second pump in a particular manufacturer's series while basing it on the known performance (or performance curve) at the point of optimum efficiency of a first and different size pump.

In effect, the performance of any impeller of a manufacturer's homologous series can be estimated from the known performance of any other impeller in the series at the point of optimum efficiency.

Essentially all the standardized conditions of specific speed of most pump manufacturers have been represented on charts available in the Standards of the Hydraulic Institute.

Acceptable design specifications for centrifugal pumps should not call for a specific speed that exceeds these standardized specific speed values. They are based on a known or fixed condition of suction lift, and relate speed, head and capacity.

This index of specific speed has been found to be a valuable guide in establishing the maximum suction lifts and minimum suction heads to avoid cavitation of the impeller. Cavitation may lead to unstable hydraulic performance and physical damage to the pump.

For a given set of conditions of the suction and discharge of a pump, a slow rotative speed pump will operate more safely at a higher suction lift than a pump of higher rotative speed.

What Fixes the Rotative Speed?

The rotative speed of a centrifugal pump is dependent upon the impeller characteristics, the fluid being pumped, the NPSH available and other factors for its final determination. The most direct method of determining rotative speed is to refer to pump perance curves supplied by the manufacturers.

When you make a seemingly reasonable selection, the effect of your speed selection on factors such as NPSH required, suction head or lift, fluid erosion and corrosion, etc., must be evaluated. For some cases, the pump speed is set by the type of driver available, such as a gasoline engine.

Pumping Systems and Performance

It's important to recognize that a centrifugal pump can operate only along its actual performance curve.[34, 35]

External conditions will adjust themselves, or must be adjusted to obtain stable operating conditions. Each pump operates within a system, and the final conditions can be anticipated if each component of the system is analyzed properly.

The pumping system consists of friction losses of the suction and the discharge piping plus the total static head from suction to final discharge point. Fig. 42 represents a typical system head curve superimposed on the characteristic curve for a 10-in. by 8-in. pump with a 12-in.-dia. impeller.

Depending upon the corrosive or scaling nature of the liquid in the pipe, it may be necessary to take this condition into account as indicated. Likewise, some pump impellers become worn with age due to the erosive action of the seemingly clean fluid and perform as though the impeller were slightly smaller in diameter. In erosive or other critical services, this should be considered at the time of pump selection.

Considering Fig. 37 on p. 194 as one situation which might apply to the system curve of Fig. 42, the total head of this system is:

$$H = D + h_{DL} - (-S - h_{SL})$$

The values of friction loss (including entrance, exit losses, pressure drop through heat exchangers, control valves and the like) are h_{SL} and h_{DL}. The total static

head is $D - (-S)$, or $[D + D' - (-S)]$ if siphon action is ignored.

Here is the design procedure involved:

1. Calculate the friction losses h_{SL} and h_{DL} for three or more arbitrarily chosen flow rates; but rates which span the interest of the system.

2. Add $[h_{SL} + h_{DL} + (D \pm S)]$ for each value of flow calculated. These are points for the system head curve.

3. Plot the capacity values in gpm. vs. the points obtained in Step 2.

4. The intersection of the system curve with the pump impeller characteristic curve is the operating point that corresponds to the total head, H. This point will change only if the external system changes.

This may be accomplished by adding resistance to flow in the system by partially closing valves, or decreasing resistance by opening valves or making pipe larger, etc.

For the system shown in Fig. 37, the total pumping head requirement is:

$$H = D + h_{DL} - (-S - H_{SL}) = D + h_{DL} + S + h_{SL}$$

The total static head of the system is $[D - (-S)]$ or $(D + S)$ and the friction loss is still $h_{DL} + h_{SL}$, which includes the heat exchanger in the system.

For a system made up of the suction side as shown in Fig. 38a and the discharge as shown in Fig. 39a, the total head is:

$$H = D + h_{DL} + P - [S - h_{SL} + P']$$

where P' is used to designate a pressure different from P. The static head is $[(D + P) - (S + P')]$, and the friction head is $h_{DL} + h_{SL}$.

Fig. 43 on p. 197 illustrates the importance of examining the system as it is intended to operate, noting that there is a wide variation in static head, and therefore, there must be a variation in the friction of the system as the gpm. delivered changes.

It is poor and perhaps erroneous design to select a pump which will handle only the average conditions, e. g., about 18 ft. of static head. Many pumps might operate at the higher 22 ft. of head when selected for the lower value. However, the flow rate might be unacceptable for the process.

Head, Horsepower, Capacity and Speed

Brake horsepower, Bhp. input at the pump is expressed by this relation:

$$\text{Bhp.} = (Q)(H)(\text{Sp. Gr.})/3{,}960E$$

where E is the pump efficiency expressed as a fraction.

For the rising type characteristic curve, the maximum brake horsepower required to drive the pump over the entire pumping range is expressed as a function of the brake horsepower at the point of maximum efficiency for any particular impeller diameter.[21]

$$\text{Bhp. (max.)} = 1.18\ (\text{Bhp. at max. efficiency point})$$

Unless specifically identified otherwise, the Bhp. values read from a manufacturer's performance curve represent the power for handling a fluid of viscosity about the same as water. To obtain actual horsepower for liquids of Sp. Gr. other than 1.0, the curve values must be multiplied by the gravity referenced to water. Viscosity corrections are discussed in a separate section of this Report.

The *driver horsepower* must be greater than the calculated (or value read from curves) input Bhp. to the shaft of the pump. Mechanical losses in the gears, V-belt fluid coupling or other drive must be accounted for so that the driver rated horsepower output will be sufficient to handle the pump.

Best practice suggests the application of a nonoverloading driver to the pump. Thus, a motor rated equal to or greater than the maximum required Bhp. of the pump, assuming no other power losses, would be nonoverloading over the entire pumping range of the impeller.

It's important to examine the pump characteristic curve and follow the changes in power requirements before selecting a driver.

A driver selected to just handle the power requirements of the design point (other than maximum) is usually a poor approach to economy. Of course, there are applications where the control system takes care of the possibilities of power overload.

Given below are two *affinity laws* that apply to the operation of centrifugal pumps:

1. For change in speed with fixed impeller design, diameter and efficiency, the following characteristics change *simultaneously:*

$$Q_2 = Q_1(n_2/n_1)$$
$$H_2 = H_1(n_2/n_1)^2$$
$$(\text{Bhp.})_2 = (\text{Bhp.})_1(n_2/n_1)^3$$

where condition of subscript 2 represents the new desired condition; condition of subscript 1 represents the condition for which a *set* of conditions are known.

These relations do not hold exactly if the ratio of speed change is greater than 1.5 to 2.0, nor do they hold if suction conditions become limiting, such as available NPSH.

Fig. 44 illustrates the application of these performance laws to the 1,750 rpm. curves (capacity, brake horsepower and efficiency) of a particular pump to arrive at the 1,450 rpm. and 1,150 rpm. curves. Note that the key value is the constant efficiency of Points 1 and 2. When the speed drops to 1,450 rpm., capacity drops:

$$Q_2 = 204(1{,}450/1{,}750) = 169 \text{ gpm.}$$

The head also drops:

$$H_2 = 64(1{,}450/1{,}750)^2 = 44 \text{ ft.}$$

and,

$$(\text{Bhp.})_2 = 6.75(1{,}450/1{,}750)^3 = 3.84 \text{ Bhp.}$$

2. For changes in impeller diameter (not design) at a fixed speed and efficiency:

$$Q_2 = Q_1(d_2/d_1)$$
$$H_2 = H_1(d_2/d_1)^2$$
$$(\text{Bhp.})_2 = (\text{Bhp.})_1(d_2/d_1)^3$$

where d_1 is the original impeller diameter in in.; and subscript 2 designates new or desired conditions corresponding to the new impeller diameter, d_2.

All performance changes occur simultaneously when converting from condition 1 to condition 2. No single condition can be true unless related to its corresponding other conditions.

An impeller can be cut from one size down to another on a lathe and, provided the change in diameter is not greater than 20%, the conditions of new operation can be described by the equations given above. A cut to reach 75-80% of the original diameter may adversely affect performance by greatly lowering the efficiency.[22]

Effect of Viscosity on Performance

When viscous liquids are handled in centrifugal pumps, the brake horsepower is increased, the head is reduced and the capacity is reduced as compared to the performance with water.

The corrections may be negligible for viscosities in the same order of magnitude as water, but they become significant above 10 centistokes for heavy materials. While calculation methods are acceptably good, for exact performance charts, tests must be run using the pump in the viscous service.

Charts are available for calculation methods. These charts allow the designer to correct the performance to a basis consistent with the conditions of the usual pump curves. A viscosity performance correction chart will be found in the Standards of the Hydraulic Institute. The Ingersoll-Rand Co., for example, has published a chart which gives the viscosity performance corrections for small pumps.

In order to use the correction curves, the following conversions are handy:

Centistokes = Centipoises/Sp. Gr.
SSU = Saybolt seconds universal
SSU = (Centistokes)(4.620) at 100 F.
SSU = (Centistokes)(4.629) at 130 F.
SSU = (Centistokes)(4.652) at 210 F.

Problem 7—Determine the proper pump selections and specifications when pumping oil of Sp. Gr. = 0.9 and viscosity of 25 cp. at the pumping temperature, if the pump must deliver 125 gpm. at 86 ft. of total head. Viscosity conversion: Centistokes = 25/0.9 = 27.8.

Solution—Using the Standards of the Hydraulic Institute, we arrive at the following correction factors: efficiency, $C_E = 0.80$; capacity, $C_Q = 0.99$; head, $C_H = 0.96$, for a 1.0 value of Q_N.

1. Note that the above correction factors represent a flow rate using water under maximum conditions of efficiency.[39]

2. Calculate approximate *water* capacity.

$$Q_W = Q_{vis}/C_Q$$
$$Q_W = 125/0.99 = 126.3$$

3. Calculate the approximate *water* head.

$$H_W = H_{vis}/C_H$$
$$H_W = 86/0.96 = 89.6 \text{ ft.}$$

4. A pump may now be selected using water as the "equivalent" fluid with capacity of 126.3 gpm. and head of 89.6 ft. The selection should be made at or very near the point (or region) of peak performance as shown on the manufacturer's curve.

5. The pump described by the curves of Fig. 35 fits these requirements. The peak efficiency is 71% using water.

6. Calculate the viscous fluid pumping efficiency:

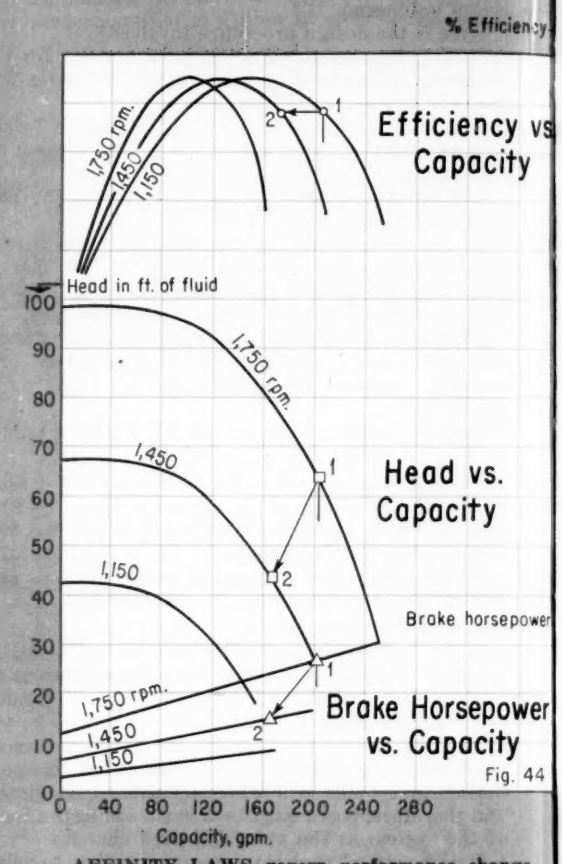
$$E_{vis} = C_E(E_W)$$
$$E_{vis} = (0.80)(71) = 56.8\%$$

7. Calculate brake horsepower for the viscous liquid.

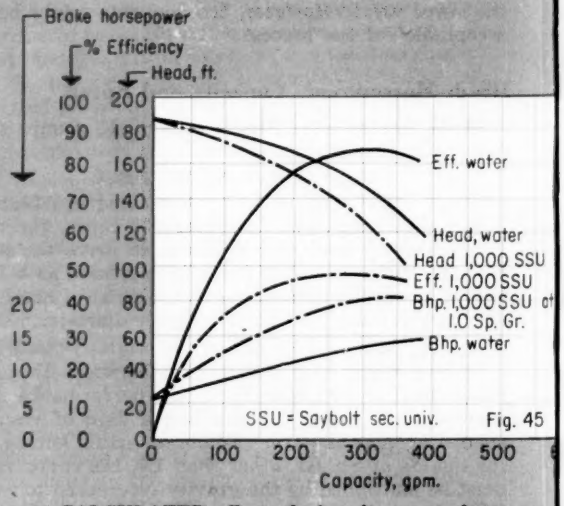
$$(\text{Bhp.})_{vis} = \frac{Q_{vis}H_{vis}(\text{Sp. Gr.})}{3{,}960E_{vis}}$$

$$(\text{Bhp.})_{vis} = \frac{(125)(86)(0.9)}{(3{,}960)(0.568)} = 4.3 \text{ Bhp.}$$

Problem 8—When a pump performance is defined for water, the corrected performance for a viscous fluid can be developed using the method described in Problem 7. In order to develop curves for viscosity



AFFINITY LAWS govern performance change.



CALCULATED effect of viscosity on performance.

Job No. _____

B/M No. _____

CENTRIFUGAL PUMP SPECIFICATIONS

SPEC. DWG. NO. A-

Page 1 of 1 Pages

Unit Price 2(one as spare)

No. Units P-68 A & B

Item No.

DESIGN DATA

Service Forwarding to T-98 Liquid 73% Caustic

% Solids None Calc. GPM 18 Des. GPM 22

Vapor Press. - PSIA Temp. 265 °F Vis. 5.9 Cp Sp. Gr. 1.68

HEAD	SUCTION	DISCHARGE	DIFFERENTIAL
Static	- 8.0 Ft.	+ 4.1 Ft.	+ 12.1 Ft.
Pressure	+ 20.2 Ft. Abs.	+ 3.4 Ft. Abs.	- 16.8 Ft.
Friction	- 0.1 Ft.	+ 199.8 Ft.	+ 199.9 Ft.
Total	+ 12.1 Ft. Abs.	+ 207.3 Ft. Abs.	+ 195.2 Ft.
NPSH Available	9.5 Ft.	Rating Head	196 to 200 Ft.

PUMP SELECTION

Mfgr. "A" Size & Type Centrifugal, 2 x 3 Model AAA Case Type Vert. split

Stages one Imp. Type Enclosed Design Imp. Dia. 13 1/8" Max. Imp. Dia. 14

Drive Motor RPM 1750 Design Eff. 73% Rotation* Counter Clockwise

Rating BHP 14.5 Non-Overload BHP 15 Shut-off Press. 143 psig NPSH Required 6 ft.

Suc. Location End Disch. Location Vertical Top Curve No. C - 1234

CONSTRUCTION MATERIALS

Case Cast 29 Cr-9 Ni, Misc. Nickel Impeller "C" 29 Cr-9 Ni, Misc. Nickel Shaft "C" Nickel

Casing Rings Nickel Shaft Sleeves None

SPECIFICATION SHEET gives pertinent data for pump selection and design—Fig. 46

conditions of 100 SSU or 1,000 SSU as shown in Fig. 45, the following general procedure is used.[29]

Solution—Here is a step-by-step description of the procedure:

1. Starting with the performance curve based on pumping water:

a. Read the water capacity and head at peak efficiency. This capacity is the value of 1.0 (Q_{nw}).

b. Using this value in gpm., calculate 0.6, 0.8 and 1.2 times this value, giving 0.6 Q_{nw}, 0.8 Q_{nw} and 1.2 Q_{nw} respectively. Then read the corresponding heads and water efficiencies.

2. Using a viscosity correction chart,[29] enter the capacity value in gpm. at a value corresponding to peak efficiency, 1.0 Q_{nw}, and follow up to the corresponding head value, H_w. Then move to the viscosity value of the liquid, and up to the correction factors C_E, C_Q and C_H.

3. Repeat Step 2 using the gpm. and head values of Step 1b.

4. Correct the head values.

$$H_{vis} = H_W C_H$$

5. Correct the efficiency values.

$$E_{vis} = E_W C_E$$

6. Correct the capacity values.

$$Q_{vis} = Q_W C_Q$$

7. Calculate the viscous Bhp. as indicated in Problem 7.

8. Plot values as generally indicated on Fig. 45 and obtain the performance curves corresponding to the viscous liquid conditions.

Temperature Rise and Minimum Flow

When a pump operates near shut-off capacity and head, or is handling a hot material at suction, it may become overheated and create serious suction as well as mechanical problems.

To avoid overheating due to low flow, a minimum gpm. rate should be recognized as necessary for proper heat dissipation. However, it is not necessarily impossible to operate at near-shut-off conditions, provided:

1. It does not operate long under these conditions, as temperature rises per min. vary from less than 1° F. to 30-40° F., or,

2. A bypass is routed or recycled from the dicharge *through* a cooling arrangement and back to suction to artificially keep a minimum safe flow through the pump while actually withdrawing a quantity below the minimum.

Temperature rise in the average pump during its normal operation is given as:[30]

$$i = H(1 - E)/778 c_p E$$

Centrifugal Pump Materials of Construction (Materials listed here are for general use

	Casing and Wear Rings	Impeller and Wear Rings	Shaft	Shaft Sleeves	Type of Seal	Seal Cage
Ammonia, anhydrous and aqueous	Cast iron	Cast iron	Carbon steel	Carbon steel	Mechanical	———
Benzene	Cast iron	Cast iron	Carbon steel	Nickel-molybdenum steel	Ring packing	Cast iron
Brine, NaCl	Ni-Resist[a]	Ni-Resist[a]	K Monel	K Monel	Ring packing	Ni-Resist[b]
Butadiene	Casing: carbon steel; Rings: cast iron	Impeller: cast iron; Rings: cast steel	Carbon steel	13% Chrome steel	Mechanical	———
Carbon tetrachloride	Cast iron	Cast iron	Carbon steel	Carbon steel	Mechanical	———
Caustic, 50%, maximum temperature 200 F.	Misco C	Misco C	18–8 stainless steel	Misco C	Ring packing	Misco C
Caustic, 50%, over 200 F.; and 73% caustic	Nickel	Nickel	Nickel or 18–8 stainless steel	Nickel	Ring packing	Nickel
Caustic, 10% with some NaCl	Cast iron	23% Cr–52% Ni stainless steel	23% Cr–52% Ni stainless steel	23% Cr–52% Ni stainless steel	Ring packing	Cast iron
Ethylene	Cast steel	Carbon steel	Carbon steel	Carbon steel	Mechanical	Cast iron
Ethylene dichloride	Cast iron	Cast iron	Steel	K Monel	Mechanical	———
Ethylene glycol	Bronze	Bronze	18–8 stainless steel	18–8 stainless steel	Ring packing	———
Hydrochloric acid, 32%	Impregnated carbon	Impregnated carbon	18–8 stainless steel	Impregnated carbon	Mechanical	———
Hydrochloric acid, 32% alternate choice	Rubber-lined cast iron	Hard rubber	Carbon steel	Rubber or plastic	Ring packing	Rubber
Methyl chloride	Cast iron	Cast iron	18–8 stainless steel	18–8 stainless steel	Mechanical	———
Propylene	Casing: cast steel; Rings: cast iron	Impeller: cast iron; Rings: cast steel	Carbon steel	Carbon steel	Mechanical	Cast iron
Sulfuric acid, below 55%	Hard-rubber-lined cast iron	Special rubber	Carbon steel	Hastelloy C	Ring packing	Special rubber
Sulfuric acid, 55 to 95%	Cast silicon-iron	Silicon-iron	Type 316 stainless steel	Silicon-iron	Ring packing	Teflon
Sulfuric acid, above 95%	Cast iron	Cast iron	Carbon steel	13% Cr steel	Mechanical	———
Styrene	Cast iron	Cast iron	Carbon steel	13% Cr steel	Ring packing	Cast iron
Water, river	Cast iron	Bronze	18–8 stainless steel	Bronze	Mechanical	Cast iron
Water, sea	Casing: 1–2% Ni–Cr, 0.3–0.5% cast iron; Rings: Ni-Resist 2B	Impeller: Monel Rings: S Monel	K Monel, aged	K Monel or Alloy 20 stainless steel	Ring packing	Monel or Alloy 20 stainless steel

in chemical process service)—Table XI

Gland	Remarks
Malleable iron	Materials of construction shown will be revised for some jobs.
Malleable iron	
Ni-Resist[b]	a. Cast iron acceptable. b. Malleable iron acceptable.
Carbon steel	
Malleable iron	
Carbon steel	Misco C manufactured by Michigan Steel Casting Co., 29% Cr–9% Ni stainless steel, or equal.
Nickel	
———	Specifications for 50% caustic, maximum temperature 200 F. are also used for this service.
Malleable iron	
K Monel	
Bronze	
Impregnated carbon	
Rubber	
Malleable iron	
Malleable iron	
Special rubber	
Silicon-iron	
Malleable iron	
Malleable iron	
Malleable iron	
Monel or Alloy 20 stainless steel	

where c_p is specific heat of the liquid being pumped, Btu./(lb.) (°F.).

When the discharge valve is completely closed, there is a temperature rise at shut-off. The following relation is simplified by eliminating the radiation from the pump casing, and it should be slightly on the conservative side when used for process design.[84]

$$\text{Temp. rise, °F./min.} = \frac{(\text{Bhp. at shut-off})(42.4)}{(\text{Wt. of liquid in pump})(c_p)}$$

The validity of a method for estimating the minimum flow has not been completely established, although the method has been used rather widely in setting approximate values for proper operation.[84]

For multistage pumps, use only the head per stage in estimating a temperature limit by this method:

a. Determine NPSH available at pump suction.

b. Add the NPSH value to the vapor pressure of the liquid at suction conditions. This represents the vapor pressure corresponding to the temperature of the liquid at flash point. Read temperature, t_2, value from vapor pressure chart of the liquid.

c. Allowable temperature rise = t_2 − actual pumping temperature. Boiler feedwater practice uses 15° F. rise for average conditions.[84]

d. Approximate minimum safe continuous flow efficiency:

$$E = \frac{H \text{ at shut-off, from curve}}{778(\Delta t)c_p + H, \text{ at shut-off}}$$

e. Read minimum safe flow in gpm. from pump performance curve *at* value of minimum efficiency calculated in Step *d* above.

Specifications for Centrifugal Pumps

Fig. 46 on p. 201 shows a design specification sheet for a centrifugal pump. Although the process engineer cannot or should not specify each item indicated, he must give the pertinent data to allow the pump manufacturer to select a pump and then identify its features.

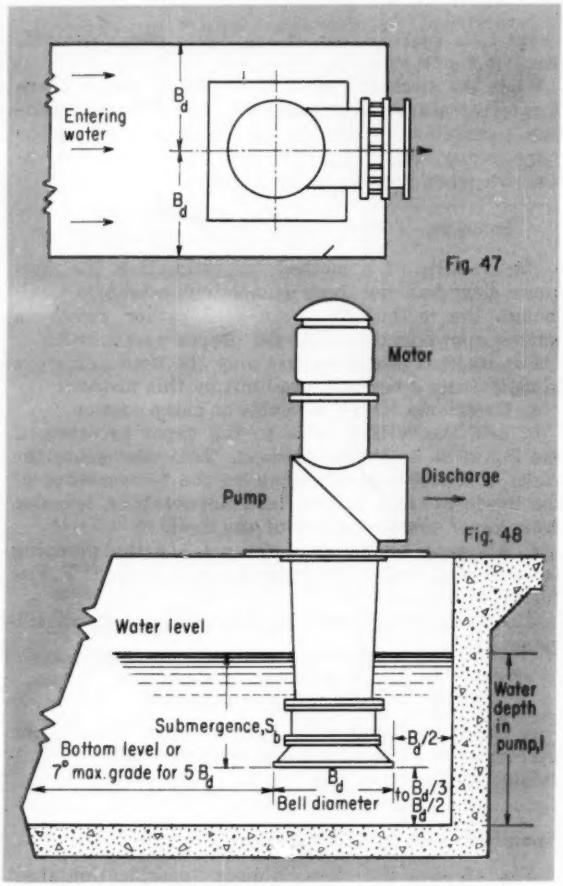
Pumps are selected for performance from the specific characteristic curves covering the casing size and impeller style and diameter.

Often the process fluids are not well known to the pump manufacturer. Therefore, the materials of construction—or at least any limitations as to composition—must be specified by the process design engineer.

The pump as specified in Fig. 46 identified the design data, key portions of the construction materials and driver data as required information for the pump manufacturer. If the pump is sent out for bids to several manufacturers this is all that is necessary.

The individual manufacturers will identify their own particular pump selection and details of construction materials and driver data. From this information a pump can be selected with performance, materials of construction and driver requirements specified.

In the example given in Fig. 46, the manufacturer has been selected from available performance curves and the details of construction must be obtained. The pump is selected to operate at 22 gpm. and 196 to 200 ft. of fluid head; and it must also perform at good efficiency at 18 gpm. and a head which has not been calculated but which will be close to the 196-200 ft., say about 185 ft.



Ordinarily, the pump is rated as shown in Fig. 46. This insures adequate capacity and head at conditions somewhat in excess of normal. In this case the design capacity was determined by adding 10% to the operating capacity and allowing for operation at 90% of the rated efficiency.

Often this latter condition is not considered. However, factors of safety of 20% are not unusual; but the efficiency must be noted and the increase in hp. recognized as safety factors are heaped on top of normal operating conditions.

Sometimes the speed of the pump is specified by the purchaser. But this should not be done unless there is experience to indicate the value of this procedure. For example, the purchaser may be concerned about the life of the pump packing and the limitation on speed may prevent the manufacturer from selecting a smaller pump.

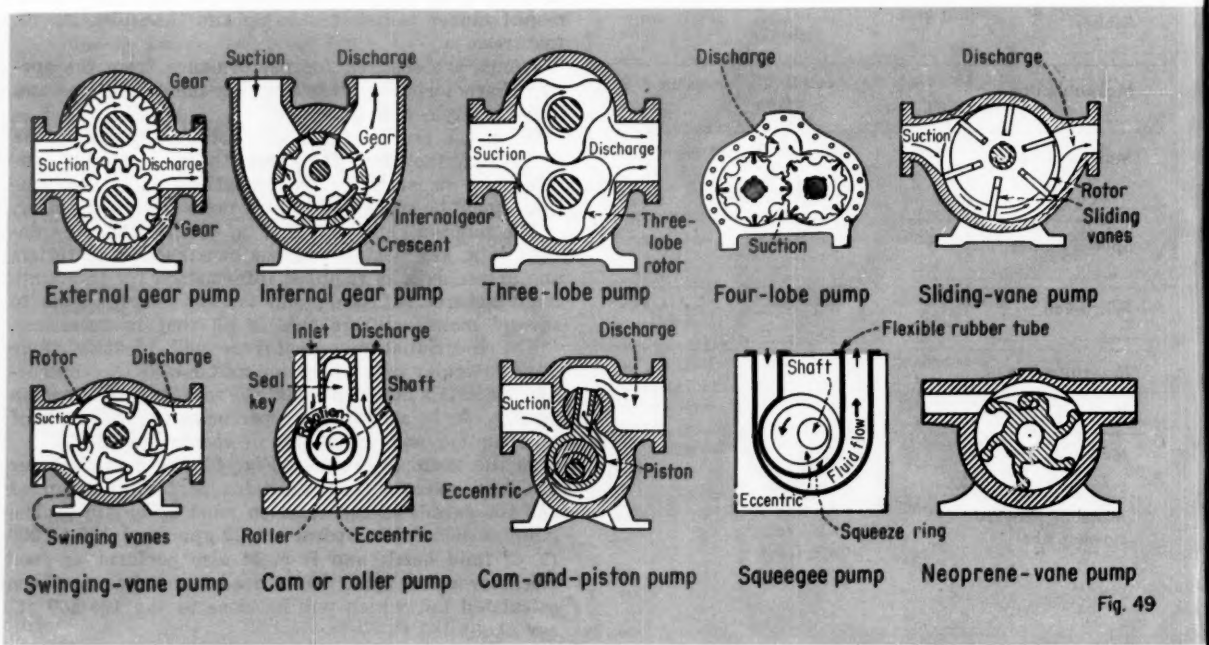
In some cases it must be recognized that high heads cannot be reached at low speeds in single-stage pumps.

Table XI on pp. 202-203 presents suggestions for materials of construction for pump parts in the services indicated. The effect of impurities, temperature, analysis variations and many other properties makes it important to obtain specific corrosion service data in the specific fluid being pumped.

Sometimes this is not possible, and generalized corrosion tables and experience of other users must be relied on as the best information available for selection of materials of construction.

Selecting the Number of Pumping Units

A single pump is the cheapest first-cost installation. However, if downtime has any value in lost production, hazard created in the rest of the process, etc., then a standby unit should be considered.



A spare or standby pump can be installed adjacent to the operating unit and switched into service on very short notice—provided it is properly maintained.

Spare pumps which do not operate often should be placed in service on a regular schedule just to be certain that they are in working order. If solids are carried in the fluid, this can present a difficult problem if they are not flushed from the pump on shutdown.

Some spare or "second' pumps are selected for 100% spare, others are selected so that each of two pumps operates in parallel on 50% of the flow, with each being capable of handling 67-75% of total load if one pump should fall off the line. This then reduces production only about 25% for a short period and is acceptable in many situations. These pumps are usually somewhat smaller than full-size spares.

When it's necessary to plan several pumps in parallel to handle a load, the pump manufacturer must be advised and care must be taken in arranging suction piping for the pumps. Otherwise each may not carry its share of the load.

There are many flow conditions and pumps should be selected to operate as efficiently as possible over the widest range of capacity. If the flow is expected to vary during the system's operation, the high and low capacities (and corresponding heads) should be given to allow proper evaluation.

Specify Fluid and System Conditions

The manufacturer must be told the conditions of the liquid, % of suspended solids, physical properties, corrosive nature and maximum and minimum temperature ranges. For extremely hot liquids, special hot pumps must be used, and extreme temperature effects must be taken into account in the basic design of the pump.

The manufacturer must know if the suction side of the pump is associated with vacuum equipment, or is to lift the liquid. This can make a difference as to the type of impeller suction opening he provides.

If the system operates intermittently it should be noted. A piping diagram is often helpful in obtaining full benefit of the manufacturer's special know-how.

If there is a preference as to horizontal or vertical split casing, it should be stated. Also, the suction and discharge connections should be specified as to top or end, or special, together with preference for flanged or screwed. Small pumps are usually furnished with screwed connections unless otherwise specified.

Pumps are usually driven by electric motors, steam or gas turbines or gas (or gasoline) engines either directly or through V-belt or gears. The pump manufacturer should know your preference. If he is to furnish the driver, data on the specification under the heading of "Driver" should be completed as far as it applies. If a gas or gasoline engine is to be used, the fuel and its condition must be stated. If air is not used for cooling, the engine cooling water must be specified in addition.

Sump Design for Vertical Lift

Proper design of sumps for use of vertical lift pumps or horizontal pumps taking suction from a sump is very important for good suction conditions at the pump.[26, 27, 37]

The arrangement and dimensions indicated in Figs. 47 and 48 are satisfactory for single- or multiple-pump installations. A few key points in sump-pump relationships for good nonvortexing conditions are:

1. Avoid sudden changes in direction or elevation of flow closer than 5 bell diameters from the pump suction side.

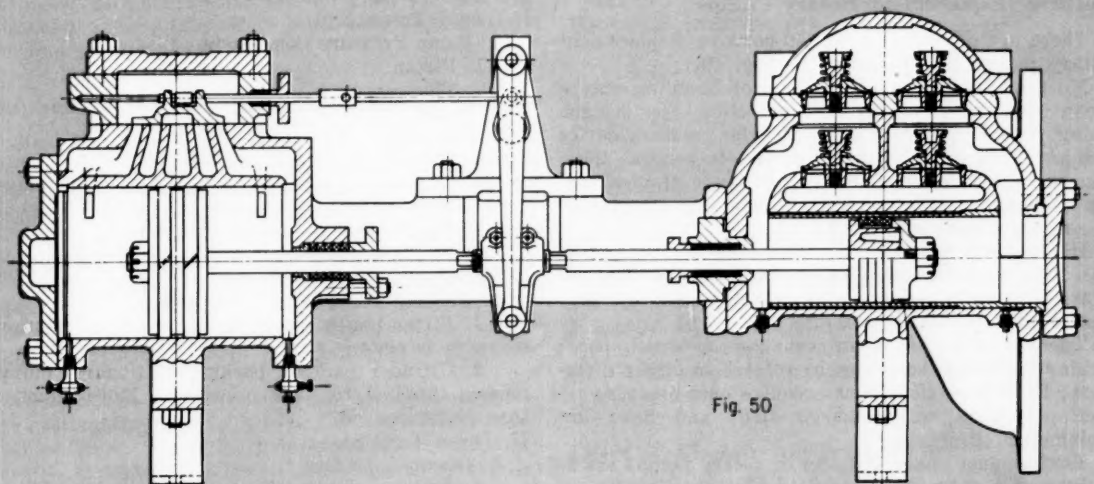


Fig. 50

ROTARY PUMPS of many types (left) are available for special applications.
RECIPROCATING PUMP arrangements vary. This (above) is a duplex, two-piston pump.

2. Avoid sump openings or projections in water path close to pump.

3. Have water flowing parallel to sump walls as it enters pump. Water should enter pump suction with as low a turbulence as possible.

4. Water velocity in sump must be low, 3 ft./sec. is good practice.

5. Inlet channel width to each pump is considered optimum at $2B_d$ to prevent secondary turbulence effects.[37]

6. Avoid placing several pumps in one open channel removing water in series fashion. If this must be done, velocity at each pump must be kept at same value as for single pump. The channel width at each pump would be calculated as follows:[38]

$$W/B_d = 1 + 4B_d(1 + 2N_p)/3l$$

where W is the width of the channel calculated at the location point of each sump.

A suction bell on the inlet of a vertical pump (or the inlet pipe of the suction side of a horizontal pump) is not necessary as far as pump operation or sump operation is concerned. If a bell is omitted, the entrance losses due to flow will be higher with only a straight pipe, and this must be considered in the design.

Economic comparison will help decide the value of the bell. Strainers should not be placed on suction bells unless this is the only possible arrangement. Inlet water should be screened with trash racks, bars and screens to keep the sump free of debris.

Submergence of the inlet pipe column or bell inlet below the water level is necessary for good operation and to prevent vortexes and entrained air. The minimum submergence as recommended by the manufacturer must be maintained at all times.

Generally, for 70 F. water each 1,000 ft. elevation above sea level adds 14 in. to required submergence. If the water is at 100 F. at sea level, approximately 17 in. must be added to the 70 F. submergence value.[37]

Positive Displacement Rotary Pumps

There are numerous types of positive displacement rotary pumps, as illustrated in Fig. 49.

Most rotary pumps are capable of handling only a clean solution essentially free of solids. The designs using rubber or plastic parts for the pressure device can handle some suspended particles. In general, these pumps handle materials of a wide range of viscosity, up to 500,000 SSU, and can develop very high pressures, over 1,000 psi.

In addition, rotary pumps can handle some vapor or dissolved gases mixed with the liquid being pumped. However, capacity is generally low per unit, and they are often used for metering.

These pumps are low in cost; require small space; are self-priming; some can be rotated in either direction; have close clearances; require over-pressure relief protection on discharge side; and have low volumetric efficiencies.[38]

Performance characteristics of rotary pumps are as follows:

1. Flow proportional to speed and almost independent of the pressure differential.

a. Internal slip reduces efficiency, and increases with pressure and decreasing viscosity.

b. Entrained gases reduce liquid capacity and cause pulsations.

c. Liquid displacement is given by:[30]

$$d' = \frac{d''(1 - E_n)}{(1 - E_n) + E_n(P/P_1)}, \text{ cu. ft./min.}$$

where P is the atmospheric pressure; and P_1 is the inlet absolute pressure to the pump.

2. Brake horsepower varies directly with pressure and speed.

3. For speed and pressure constant, Bhp. varies directly with viscosity.

Selecting a Rotary Pump

Suction and discharge heads for rotary pumps are determined as for centrifugal pumps. The total head and capacity are used in selecting the proper rotary pump from manufacturer's data or curves.

Since viscosity is very important in the selection of these pumps, it's sometimes better to select a larger pump running at low speeds than a smaller pump at high speeds when dealing with viscous materials.

As a general guide, speed is reduced 25 to 35% below rating for each ten-fold increase in viscosity above 1,000 SSU. Also, generally, the mechanical efficiency of the pump is decreased 10% for each ten-fold increase in viscosity above 1,000 SSU, and referenced to a maximum efficiency of 55% at this point.[38]

Selection of Reciprocating Pumps

Reciprocating pumps are positive displacement piston units driven by a direct-connected steam cylinder or by an external power source connected to the crankshaft of the pump piston.

Since they are positive displacement, these pumps can develop very high pressures (10,000 psi. and higher) for very low or high capacities (up to 1,000 gpm.).

Given below is an outline of the significant features in reciprocating pump arrangements:

I. Liquid Pump End
  A. Pump Pressure Component
    1. Piston.
    2. Plunger.
  B. Types
    1. Simplex, one-piston.
    2. Duplex, two-piston, see Fig. 50.
    3. Triplex, three-piston, not used as steam driven.
  C. Piston or Plunger Action
    1. Single-acting, one stroke/rpm.
    2. Double-acting, two strokes/rpm., cylinder fills and discharges on each stroke.
  D. Packing for Piston or Plunger
    1. Piston packed; packing mounted on piston and moves with piston. Applied to fairly low pressures.
    2. Cylinder packed; packing stationary, plunger moves. Applied to high pressures. More expensive than piston packed.

II. Drive End: Steam
  A. Steam Cylinders
    1. Simple; single cylinder per cylinder of liquid pump. Uses more steam than compound.
    2. Tandem compound; high and low pressure cylinder on same centerline. Usually requires 80 psi. or more steam to be economical.

3. Cross compound; high and low pressure cylinder arranged side by side with cranks 90° apart. Need for crank and flywheel arrangement only, usually requires 80 psi. or more steam to be economical. The % gain in compounding steam cylinders varies from 25 to 35% for noncondensing, and 25 to 40% for condensing.

B. Cylinder Action

1. Direct; steam piston direct connected to liquid piston or plunger through piston rod.

2. Crank and flywheel; flywheel mounted on crankshaft driven by steam cylinder.

III. Drive End: Power

General features same as steam, except drive always through crankshaft, speed gear increasers or reducers, V-belts or direct coupling connection to driveshaft of the pump

IV. Designation

Units are identified as: (steam cylinder dia., in.) (liquid cylinder dia., in.) (length of stroke, in.)

Application of Reciprocating Units

Piston Type—This type of liquid end is used for low-pressure, light-duty or intermittent service. Is less expensive than the plunger design, but cannot handle gritty liquids.

Plunger Type—This liquid end is used for high-pressure, heavy-duty or continuous service. Is suitable for gritty and foreign-material service. Is more expensive than the piston design.

Liquid Valves—The disk, wing and spherical valves are the most common. The disk valve is the most generally applicable, and in services carrying suspended particles, the valve is designed with soft seats of rubber, plastic, lead, etc., to allow for proper seating. The wing valve is generally used for pressures higher than those of the disk design.

Cylinder Liners—Depending upon the nature and physical characteristics of the liquid (suspended grit, viscosity, corrosive nature) the cylinders are often equipped with replaceable liners. When the performance of the pump falls off, or other conditions indicate, the liners are replaced.

Materials of Construction: Reciprocals

Steam-end construction materials are well standardized for various pressure ratings and usually need no special design attention, unless the motive steam has impurities which might be troublesome.

The liquid-end construction requires close attention to provide for proper handling of the erosive, corrosive and physical property characteristics of the liquid.

A standard fit-up usually consists of cast iron or steel with some bronze parts, or all iron or all bronze parts.

There can be many special arrangements as to cylinder casting (or forging if high pressure) material as well as liners. Often the liners are made of more expensive material to allow a less expensive material for the main casting.

Erosion and corrosion are usually accelerated only at points or areas of high fluid velocity, rubbing or movement. Some chemicals are not well suited to reciprocating pump design due to the difficulty in handling the corrosion in materials of sufficient strength and hardness.

Piston rods are usually of high-strength steel and may be plated for some services. Some stainless or nonferrous rods may be required.

Reciprocating Pump Performance

Performance of reciprocating pumps provides for ease of operation and control. Depending upon the type of piston action, the fluid may be subject to pulsations unless accumulator or surge drums are provided.

The slip of a pump is fraction or % loss of capacity relative to theoretical. Slip $= 1 - E_{vol}$, where E_{vol} is the volumetric efficiency. Volumetric efficiency is the actual liquid pumped (usually considered as water) relative to that which should theoretically be pumped based on piston displacement.

Capacity of a pump is given in manufacturers' tables as actual, after deducting for volume occupied by piston rod and slippage. Slip varies from 2 to 10% of displacement, with 3% being a fair average.

Actual capacity for single-acting, single-cylinder pumps is given by:

$$Q = \frac{(12al)(E_{vol})}{(231)(2)} = 0.0204 d_p^2 l E_{vol}, \text{ gpm.}$$

For double-acting, single-cylinder pumps, Q is twice the value for single-acting less $0.0204\ d_r^2 t$, gpm. For multiple cylinders, multiply the capacities obtained above by the number of cylinders. If the piston rod does not replace pumping volume as in some arrangements, the negative term of the double-acting equation can be omitted.

Piston speed is the ft./min. of piston travel in the cylinder while pumping. For steam pumps:

$$l = (\text{strokes/min.})(s)/12, \text{ ft./min.}$$

For power pumps:

$$l = (\text{rpm.})(s)/12, \text{ ft./min.}$$

Selected recommended piston speeds as given by the Hydraulic Institute are:[40]

Stroke, In.	Ft./Min. For Simplex Or Duplex Steam Pumps
6	59
10	75
20	100

For power pumps the Hydraulic Institute also recommends basic speed values referenced to stroke. The values are not the same as for steam pumps.

One disadvantage of selecting a reciprocating pump for a process flow system is the pulsating flow delivered by this type of pump.

Unless the pump selected has multiple cylinders or a special drive mechanism—either of which greatly increases expense—accumulator bottles would be required in the system to smooth out the flow. Manufacturers can supply curves for discharge flow patterns.

Effect of Viscosity or Temperature

High viscosity or high temperature in a reciprocating pump reduces its capacity by reducing its allowable operating speed. For illustration, the following corrections were read from a chart published by the Hydraulic Institute:[40]

Viscosity, SSU,	Or Temperature, °F.	% Basic Speed
250	70	100
3,000	126	74.5
6,000	262	61.5
10,000	650	50.0

To calculate the horsepower required by a reciprocating pump, you can use these formulas:

$$\text{Hydraulic hp.} = (Q \text{ actual})(H)/3{,}960$$

$$\text{Brake horsepower} = \text{Hydraulic hp.}/\text{Efficiency}$$

where E represents the total over-all efficiency; and $E = E_m\ (E_{v.i})$; and E_m is the mechanical efficiency.

Mechanical efficiencies of steam pumps vary with the type of pump, stroke and pressure differential. Some representative values are 55 to 80% for piston pumps with strokes of 3-in. and 24-in. respectively, and pressure differential up to 300 psi.

For the same strokes a plunger design varies from 50 to 78% and at over 300 psi. differential the efficiencies are 41 to 67%.[38] Steam required is approximately 120 lb./(hr.)(Bhp.).

Fundamentals of Pump Selection

Reciprocating pump selection follows the fundamentals of centrifugal pump selection:

1. Evaluate suction-side head loss.
2. Evaluate discharge-side head loss.
3. Determine system static pressure.
4. Determine total differential head across pump.
5. From manufacturer's performance tables, select pump nearest to capacity and head requirements.
6. Contact manufacturer for final recommendations, give complete system requirements and physical properties of liquid being pumped.

To reduce the effect of pulsation, accumulator tanks are often used on the discharge of reciprocating pumps. These tanks are used on the suction side when the volumes handled are large.

Air bottles built as part of some pump styles serve to accomplish the same purpose, but may not be sufficient for systems having fine instrument control. The manufacturer should be consulted as to the recommendations for his various pump styles.

For Further Details: See the Book

Because of space limitations, it obviously has not been possible to include in this Report many additional process design details for flow of fluids and about pumping of fluids.

Additional information will be included in the author's forthcoming book on process design. See p. 162.

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A New Guide to . . .

Filter Media

A tiny filter for aircraft and a giant for nuclear reactors—only two of many filters and filter media developed in recent years.

JULES P. KOVACS, Vice Pres., Purolator Products, Rahway, N. J.

When someone mentions filters, you may think of a cigarette filter tip or perhaps the familiar oil filters that are standard equipment on automobile engines. You might also think of paper or ceramic laboratory filters or the metal edge units widely used in industry.

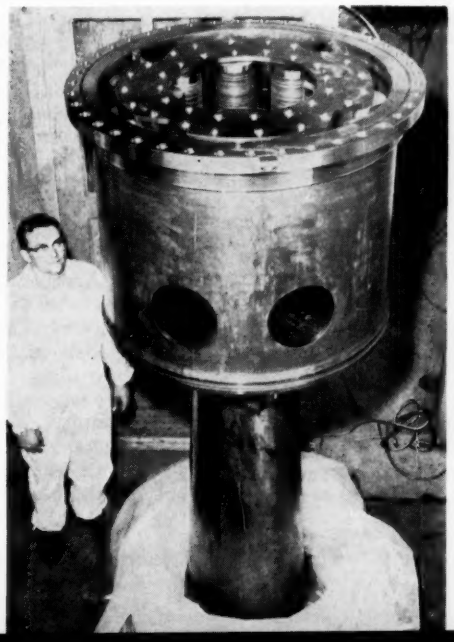
There is much more to filters and filter media than these few examples, however—great progress has been made in the development of both in the last few years. But the area where progress has been greatest is not so much in filters themselves as in filter media. Through these advances practically any product that can be handled at all—liquid or gas—can now be filtered successfully.

Highly alloyed metals are solving problems of corrosion, high temperature, extreme pressure, thermal or mechanical shock and of handling radioactive materials. These are the same metals that perform satisfactorily in processing units, piping, valves, heat exchangers and other equipment. You can use them in construction of the entire filter—case, baffles, mechanical supports and the element itself.

Metal screens and strainers will remove particles down to several thousandths of an inch in size, but the new porous metal media can be made with minute pores that will filter particles as small as one or two microns (10^{-6} meters). These new media, along with more traditional media, ceramics and certain new plastics, cover almost the complete range of filterable gases and liquids.

There is far more to a filter than an element of suitable area enclosed in a case with inlet and outlet connections. Effect of temperature, pressure or vacuum, shock loads and vibration must be considered. How will you handle filtered solids? When the job involves radioactivity and disposal of "hot" material, it becomes vitally important that designs be based on experience and study.

Cuno



Filtration Saves Money

One result of recent technological advances in filtration is cost savings. For example, separations can be done in many ways, most of them far more expensive than filtration, such as fractionation, electrostatic precipitation and dynamic methods that depend on differences in mass or density.

In one case a porous metal filter now removes impurities from a high temperature gas stream before the vapor condenses to a liquid. If the extremes of temperature and pressure had made it impractical to filter the gas, elaborate chemical processing would have been necessary to purify the liquid because some of the impurities are soluble in the liquid.

In another example contaminants in a liquid are frozen to solid particles in the liquid and filtered.

Filters are finding new roles in combina-

tion with other techniques. Filter case design often incorporates inertia and impingment separation. Filters are often built with several stage effects in which particles are agglomerated or coalesced before filtering, selectively absorbed or adsorbed and sometimes decomposed catalytically.

Though such complex units take advantage of chemical processing techniques, the basic final process is filtration and the economics of this method is retained.

Now that filters with pore sizes of a few microns can operate wherever metal equipment is satisfactory, filtration must be given serious consideration wherever separation is required. Five or ten years ago, the range of filter applications was usually governed by what organic filter media could stand and separation problems outside that range were handled by other processes.

In this article we will attempt to point out and describe briefly new filter media—including some standard materials—which have been employed with success in filtration problems. Fig. 1 is a summary of the principal classes of filter media which we discuss below.

Impregnated Cellulose Media

Impregnated cellulose elements can provide micronic filtration at moderate temperatures and pressures most economically. This material is essentially a special grade of filter paper impregnated with synthetic resin, usually a phenolic.

Elements of this material are widely used for air, water, oils, solvents, fuels, gases and some process chemicals. The public is most familiar with them as oil filters and carburetor air cleaners on their cars.

These elements are versatile. Pore size is controllable, ranging from 2 to 25 microns. Pressure drop is low and a large filter area can be provided in a small space with the "extended area" principle (accordian pleating of the paper.)

As long as the pressure drop across the filter element itself does not exceed 100 psi. or so, the system pressure inside the filter case can be several thousand psi. Maximum service temperature is about 200 F., but special impregnants can raise this limit if necessary. They have also been used successfully at temperatures as low as −100 F.

Screen and Wire Cloth

We can now manufacture woven wire cloth in pore sizes as small as 2 microns, these very fine screens being generally made of stainless steel or Monel. Like impregnated cellulose media, this material can be formed to provide a large flow area in a small space with the "extended area" principle.

Such screens are used extensively in high pressure hydraulic and pneumatic systems in aircraft and missiles but they are generally limited to such applications because of their high cost. They have excellent possibilities as filter media where small amounts of contaminant are involved.

Wire cloth can be made sufficiently ductile for forming into many shapes and forms and it has attractive potentialities as a flexible matrix or support for a ductile porous metal coating.

In coarser screens, 200 to 250 mesh, you can obtain woven wire screens in stainless, Monel and other alloys at relatively low cost. This material when properly handled can also be made a flexible support for a ductile, extremely thin porous metal coating giving micronic filtration as desired. It, too, may be folded and formed in many shapes.

Metal-Edge Media

A metal-edge filter medium is essentially a flat metal ribbon wound upon itself like a spring. In one type, regularly spaced formed projections on one surface of the ribbon prevent the metal from contacting when the "spring" is compressed. These projections may be tapered so that the slot so formed will also taper. This feature prevents clogging—particles which can enter the slot will pass through, those that cannot pass will remain on the surface.

Flow may be in either direction depending on whether the formed wire is wound with slots tapering from inside or outside.

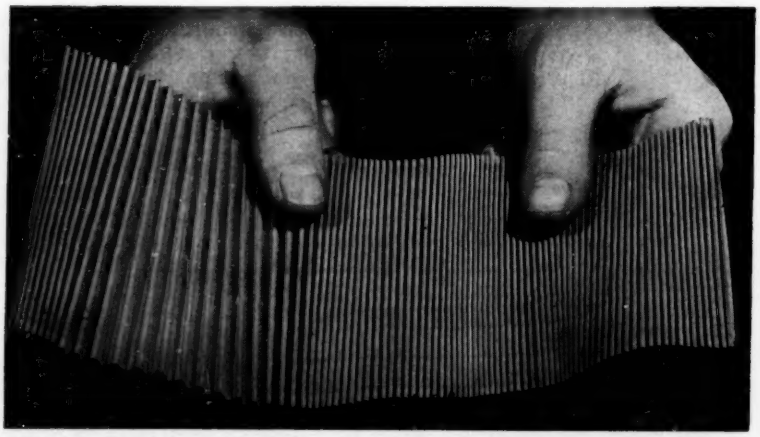
Usually, metal edge elements are cylindrical but flat elements can be made by cutting and unrolling a cylindrical element. If loads in service call for extra strength, stiffness and shock resistance, the normally self-supporting element can be reinforced with frames of welded bars. Properly designed elements can bear great pressure differentials across the element.

Slot sizes range from a few thousandths of an inch to about 0.025 in.

Fused Porous Metal

Another type of metal element is that made from sintered metal powder. These elements can be produced with controlled pore sizes, providing filtration of particles from 40 microns to the sub-micron range. Pore sizes are highly uniform.

Standard pore sizes are 4, 8, 12 and 25 microns, but other sizes can



POROUS metal elements can be made so flexible that they can be folded into "extended area" or convoluted shapes in the same manner as paper elements.

Table Summarizes Filter Media Data

Medium	Range of Pore Sizes	Open Area, %	Thickness Range, In.	Operating Temperature, Deg. F.	Pressure Drop, Max. Psi.	System Max. Operating Pressure, Psi.	Backwash Pressure, Max. Psi.	Common Element Forms	Remarks
Resin-impregnated cellulose	2 to 25 microns	.....	.010" to .060"	—100 to 250	100	10,000	not usually practical	convolute	element commonly replaced instead of being cleaned by backwashing when loaded
Wire cloth	5 microns and coarser	varies, with pore size	varies, twice wire size	—420 to 1200 (depends on metal used)	up to 3000 (under special conditions)	10,000	not usually practical unless flat or cylindrical	cylindrical, convolute or flat	
Metal-edge	.001" to .025"	varies with pore size	.010" to 5/32"	—420 to 1200 (depends on metal used)	up to 2000 (depends on supports)	10,000	100	cylindrical	can be self-supporting or reinforced by frame
Fused porous metal	4, 8, 12 and 25 microns are std.	50% to 60%	normally .020" to .060", specials from .006" up	—420 to 1200 (depends on metal used)	depends on size and shape	10,000	100	cylindrical, convolute, tubular or flat	
Fused metallic fibers	4, 8, 12 and 25 microns are std.	50% to 60%	1/16" and thicker	—420 to 1200 (depends on metal used)	depends on size and shape	10,000	100	usually flat disc or sheet	
Fused porous metal coatings	4, 8, 12 and 25 microns are std.	50% to 60%	.006" to 1/8"	—420 to 1200 (depends on metal used)	up to 2000 (depends on supports)	10,000	100	cylindrical, convolute or flat	may be on metal-edge or wire cloth support
Fused metallic fiber coatings	4, 8, 12 and 25 microns are std.	50% to 60%	.016" and thicker	—420 to 1200 (depends on metal used)	up to 2000 (depends on supports)	10,000	100	cylindrical, convolute	may be on metal-edge or wire cloth support
Glass fibers	5 microns (matted) to 100 microns	.....	.....	—100 to 800	.....	10,000	not usually practical	woven, knitted or packed fibers	
Nylon	5 microns (matted) to 100 microns	.....	.....	—100 to 300	.....	3,000	not usually practical	woven, knitted or packed fibers	
Orlon	5 microns (matted) to 100 microns	.....	.....	—100 to 300	.....	10,000	not usually practical	woven, knitted or packed fibers	
Dynel	5 microns (matted) to 100 microns	.....	.....	—100 to 200	.....	10,000	not usually practical	woven, knitted or packed fibers	
Ceramic	2 to 100 microns	.....	.....	over 1800	55	2,000	not usually practical	cylindrical	heat-up and cool-down should not exceed 390 F./hr.

Flow rate and pressure drop (Δp) is predicted upon(1) Pressure drop (Δp) through exit nozzle and its length; (2) equal pore size and number of pores per square inch of any given material linearly as its thickness will vary; (3) flow medium viscosity and density; (4) ideal conditions to have greatest effective filtration area and minimum depth of medium for given flow to keep velocities at minimum; and (5) consideration of other existing process and physical conditions.

be provided to fit special requirements.

These elements have excellent mechanical properties; ductility and strength are remarkable for a sintered material. Sections from 0.01 in. to ¼ in. and more in wall thickness can be flexed, bent and, to some extent, formed at room temperature. Thus we can make elements in many shapes such as flat plates, cylinders, convoluted tubular sections and others.

We can join porous metal parts to solid metal of the same alloy with a special fusing process. The solid metal can then be welded making it practicable to build large, complex filter assemblies of almost any shape or design.

Porous metal elements can be pro-

duced in a sufficiently wide choice of metals and alloys to meet virtually any corrosion resistance requirement possible with metals. These include iron, stainless steels, nickel, bronze, Monel, Inconel, Hastelloy, gold and others.

Fused Metallic Fiber

Akin to porous metal media are elements made from fused metal fibers. For some applications elements with an interlocked fibrous structure offer advantages over those produced by powder metallurgy. The most notable benefit of fibrous construction is the great resistance to shock.

Current manufacturing processes limit metallic fiber elements to simple shapes—flat plates or discs—but these can be fused together to form more complex elements. Greater thicknesses are feasible than with powder metallurgy. Elements can be one inch thick or more.

Pore sizes are larger than those of sintered powder media, ranging from 10 to 60 microns.

These units, because of their fibrous structure, offer greater permeability (less flow resistance) per unit of measure than do the sintered metal units.

Coated Elements

We can combine the small pore sizes of porous metal elements with the mechanical strength of metal-edge elements.

A layer of porous metal of the required thickness is bonded to the upstream face of the metal-edge element. This layer can be any desired thickness—commonly from 0.010 to 0.020 in. It may penetrate the slots between the metal-edge ribbons or may be just on the surface with nominally zero penetration if desired.

Both the coating and the supporting ribbon are of the same metal or alloy for a given element. The coating material is usually metallic powder fused to the metal ribbon.

Filtration characteristics are those of the coating. Slot width is adequate to handle anticipated flow but the supporting metal-edge element has little effect on degree of filtration or pressure drop.

Another coated element that can be bent and folded as readily as paper is produced by coating fine mesh metal screen. Again, the coating is the same metal or alloy as the supporting wire cloth.

Pressure drop and degree of filtration are again functions of coating thickness and pore size both of which can be precisely controlled.

Some Fiber Media

Woven and non-woven glass fibers form filter media for special applications. Freedom from corrosion in most environments and temperature resistance up to 800 F. are their desirable characteristics.

Degree of filtration can range from 5 to 500 microns. Strictly speaking, however, these media do not have a "pore size" and do not have the same predictable uniformity in this respect as do the impregnated cellulose, porous metal and metal-edge media.

Synthetic fibers are used for filtration as woven cloth, knitted fabrics and in non-woven form.

Among the suitable materials are Dynel, nylon, polyethylene, polypropylene and others, the choice depending on corrosion, compatibility and temperature considerations.

Degree of filtration may be from 5 to 100 microns. As with glass fiber media, these media do not have great uniformity in pore size.

Cotton and wool are among the oldest of filter media. Depending on thickness and manner of use, they can operate as combination surface and absorption filters or, when shredded and poured into cans, as depth type adsorption filters.

Cloth types can be made into extended area shapes and can also be made removable and washable. It is generally impractical to remove contaminants with back-washing.

Chemical treatments and resin impregnation can improve the characteristics of natural fiber filter media. In this manner, you can alter the wetting characteristics of the fibers and adapt these media to the special applications they still find in modern practice.

Absorbing and Adsorbing Media

Absorbing and adsorbing media would include such materials as activated charcoal, silica gel, activated alumina and diatomaceous earth. These may be found in fluidized beds or in static filter elements.

Activated charcoal, for example, can be incorporated into a fibrous filter element. On the other hand, activated alumina works better in a fluidized bed.

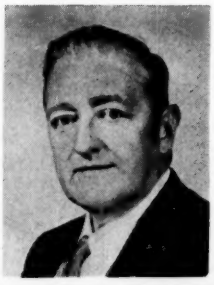
Ceramics and Refractories

Filters are made from fused porous ceramics as well as porous metal. Materials such as fused silicon carbide resist extremely high temperatures and many chemicals that corrode metals. However, these materials have poor resistance to thermal and mechanical shock and low mechanical strength.

Mechanical strength depends to a large degree on the grade of material (being higher in the finer grades) and the shape of the element. Ceramics are stronger in compression than in tension, a factor you should take into account when designing a ceramic filter or installing a ceramic element.

Though these filters may be operated at temperatures as high as 1,800 F., the rate of temperature change should not be greater than about 390 F./hr. to avoid thermal shock.

Unlike porous metals, particles in a porous ceramic may be quite irregular in shape and size. However, because of the complexity of the channels between the particles, quite uniform filtration can be obtained down to the sub-micron range.



JULES P. KOVACS joined Purolator Products in 1929 as a design engineer, later became assistant chief engineer and chief engineer and was named a company vice president for research and development in 1950. In 1958, he became vice president in charge of technical sales.

Mr. Kovacs is a licensed professional engineer, author and inventor. He is a member of the National Society of Professional Engineers, Society of Automotive Engineers and the Technical Association of the Pulp and Paper Industry.

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Use Numerical Methods of Analysis

Analytical solutions to equations may not be possible for many problems in unsteady state heat transfer; but mathematical or physical approximations yield numerical, approximate answers.

SAM H. DAVIS, JR., Rice Institute, Houston, Tex.*

Starting point in the numerical solution of most problems which are too complicated to be solved analytically is the determination of a mathematical or physical approximation to the actual problem. The mathematical approach involves the selection of approximate analytical expressions for each unknown or arbitrary function of the variables in the problem. If the type of analytical expression is suitably chosen, it is then possible to reduce the complexity sufficiently to obtain numerical, approximate answers.

The most frequently encountered operations in unsteady state heat transfer are: (1) interpolation or extrapolation of experimental data, (2) integration with respect to the independent variable and (3) differentiation with respect to the independent variables.

Select Suitable Polynomial Approximations

An obvious method for trying to insure agreement between two functions is to choose several values of the independent variable for which approximate or exact numerical values of the function are known and to determine the free parameters in the polynomial such that it will take on identical values at these same points. A familiar example of this method is linear interpolation between tabular points in tables of transcendental functions.

In linear interpolation the two points which bracket the given value of the independent variable are effectively used to determine a binomial which then forms the basis for interpolation. The following discussion treats the more general operations which may use any number of data points for interpolation.

If an unknown function of time is represented by $f(t)$ and $y_n(t)$ is a polynomial of order n, $y_n(t)$ may be made to coincide with $f(t)$ at $(n + 1)$ distinct values of t. If $(n + 1)$ values of $f(t)$ are known or have been calculated by some approximate means, the polynomial which takes on these same values may be represented in Lagrangian form by:

$$y_n(t) = \sum_{k=0}^{k=n} \frac{\pi(t) f(t_k)}{(t - t_k)\pi'(t_k)} = \sum_{k=0}^{k=n} l_k(t) f(t_k) \qquad (1)$$

where

$$\pi(t) \equiv (t - t_0)(t - t_1) \cdots (t - t_n)$$
$$\pi'(t_k) \equiv (t_k - t_0) \cdots (t_k - t_{k-1})(t_k - t_{k+1}) \cdots (t_k - t_n)$$

The derivation of Eq. (1) is given in many texts on numerical analysis.[2, 3, 5] That Eq. (1) takes on the value $f(t_j)$ for $t = t_j$ may be readily checked by substitution since $l_k(t_j) = 0$ for $k \neq j$ and $\lim l_k(t) = 1$ as t approaches t_k.

Eq. (1) may be used for interpolation, integration or differentiation. One difficulty in using Eq. (1) for any of these operations is in estimating the error inherent in its use. This error represents the difference between $y_n(t)$ and $f(t)$. A short discussion of this problem will be given at the end of the article. For a more complete discussion see References 3, 4 and 5.

Eq. (1) may be simplified if the values of t_k are evenly spaced. Thus, if

$$t_k = t_0 + k\,\Delta t \qquad (2)$$

and we define s by the relation

$$t = t_0 + s\,\Delta t$$

Eq. (1) may be rewritten as:

$$y_n(s) = \sum_{k=0}^{k=n} \frac{s(s-1) \cdots (s-n) f_k}{(s-k)k(k-1) \cdots (1)(-1) \cdots (k-n)} \qquad (3)$$

where $f_k = f(t_k)$.

For example: with $n = 2$, Eq. (3) becomes:

$$y_2(s) = \frac{s^2-3s+2}{2} f_0 - (s^2-2s) f_1 + \frac{(s^2-s)}{2} f_2 \qquad (4)$$

An alternate form of Eq. (4) is:

$$y_2(s) = \frac{(f_0-2f_1+f_2)}{2} s^2 - \frac{(3f_0-4f_1+f_2)}{2} s + f_0 \qquad (5)$$

Eq. (4) or (5) may be readily integrated or differentiated. For example, the integral of Eq. (4) may be used to determine

$$\int_{t_0}^{t_2} y_2(t)\,dt = \frac{\Delta t}{3}(f_0 + 4f_1 + f_2) \qquad (6)$$

Eq. (6) is the parabolic integration formula known as Simpson's rule.

Differential of $y_2(t)$ with respect to t at center point t_1 is:

* To meet your author, see *Chem. Eng.*, Apr. 18, 1960, p. 188.

$$\left(\frac{dy_2}{dt}\right)_{t=t1} = \frac{f_2 - f_o}{2\,\Delta t} \tag{7}$$

and at the end points is:

$$\left(\frac{dy_2}{dt}\right)_{t=to} = \frac{-(3f_o - 4f_1 + f_2)}{2\,\Delta t} \tag{8}$$

$$\left(\frac{dy_2}{dt}\right)_{t=t2} = \frac{f_o - 4f_1 + 3f_2}{2\,\Delta t} \tag{9}$$

Example Illustrates Methods

A liquid is heated in a continuous flow process by condensing steam inside coils. The liquid flows into a well-stirred tank in which the coils are immersed. Estimate the time required for the outlet temperature to change a given amount following a rapid change in the inlet temperature.

An energy balance around the liquid hold-up in the heater is:

$$c_p \frac{d(TM)}{dt} = UA(T_s - T) + m_i c_p T_i - m_o c_p T \tag{10}$$

where

- M Mass of liquid in the tank.
- T Liquid temperature.
- T_i Temperature of liquid entering tank.
- m_i Mass flow rate into tank.
- m_o Mass flow rate from tank.
- U Average over-all heat transfer coefficient between steam and liquid
- A Area for heat exchange.
- c_p Assumed constant heat capacity of the liquid.

Eq. (10) neglects the heat capacity of the coils and any exchange of heat between the liquid and the walls of the tank. The equation may be rearranged by use of a material balance so that:

$$Mc_p \frac{dT}{dt} = UA(T_s - T) + m_i c_p (T_i - T) \tag{11}$$

Eq. (11) may be solved in a simpler manner if it is first made dimensionless by substituting:

$$d\phi = m_i\,dt/M$$
$$\theta = (T - T_s)/(T_i - T_s)$$
$$\alpha = UA/m_i c_p$$

The energy balance now becomes:

$$\frac{d\theta}{d\phi} = -(\alpha + 1)\theta + 1 \tag{12}$$

Eq. (12) may be readily solved by standard analytical methods if α is constant. For future reference this solution is:

$$\theta = \frac{1}{1+\alpha} + \left[\theta_o - \frac{1}{1+\alpha}\right] e^{-(1+\alpha)\phi} \tag{13}$$

where θ_o is the value of θ at $\phi = 0$.

If U is a function of the liquid temperature, α will depend on θ and the solution of Eq. (12) must be expressed as:

$$\int_0^{\phi_1} = \int_{\theta_o}^{\theta_1} \frac{d\theta}{-(\alpha+1)\theta + 1} \tag{14}$$

If the variation in α with temperature is known only through experimental evidence obtained at a few values of T, evaluation of the integral on the right hand side of Eq. (14) may require both numerical interpolation and numerical integration. As an example of this condition, the following data might be obtained for the heating of a viscous oil in the temperature range 68 to 212 F.

T, °F.	68	104	140	176	212
α	1.13	1.05	1.00	0.96	0.93

With $T_s = 212$ F. and $T_i = 90$ F., the tabular values of θ are 1.180, 0.885, 0.590, 0.295 and 0.

Using the temperatures 68, 140 and 212 F. in Eq. (5) gives the following approximate relation between α and θ.

$$\alpha = 0.08619\theta^2 + 0.0678\theta + 0.930 \tag{15}$$

Calculating values of α from Eq. (15) for the values of θ previously given yield these results:

θ	1.180	0.885	0.590	0.295	0
α	1.130	1.058	1.000	0.958	0.930

By comparing the intermediate points found experimentally with the calculated values above, we find that Eq. (15) adequately represents the given data.

If the initial tank temperature is 140 F. (representing an initial steady state condition with $T_i = 68$ F.), the time required for θ to reach any value θ_1 may be determined by evaluating the integrals

$$\int_0^{t_1} \frac{m_i\,dt}{M} = \int_{0.590}^{\theta_1} \frac{d\theta}{-(1.93 + 0.0678\theta + 0.08619\theta^2)\theta + 1} \tag{16}$$

If m_i and M are constants, evaluation of the left side

Nomenclature

A	Area.
c_p	Specific heat.
F	Function of.
f	Function of time.
k	Number of time increments corresponding to $(t_k - t_o)/\Delta t$.
M	Mass of fluid.
m_i	Inlet mass flow rate.
m_o	Outlet mass flow rate.
s	Dimensionless independent variable corresponding to $(t - t_o)/\Delta t$.
t	Time.
T	Temperature.
U	Over-all heat transfer coefficient.
y	Appromixation for f.
α	Dimensionless parameter corresponding to $UA/m_i\,c_p$ or $UA/m_i{}^o\,c_p$.
Δ	Difference operator.
θ	Dimensionless dependent variable corresponding to $(T - T_s)/(T_i - T_s)$.
π	Defined such that $\pi(t) = (t - t_0)(t - t_1) \ldots (t - t_n)$.
ϕ	Defined such that $d\phi = m_i dt/M$ or $d\phi = m_i{}^o\,dt/M^o$.

Subscripts

$0, 1, 2 \ldots n$	Particular values of variables.
j, k	General indexes.
n	Order of approximation.

Superscripts

i	Approximation after i iterations.
o	Initial value of.

Compare Results of Methods—Table I

	Open Method, Eq. (21)			Closed Method, Eq. (25)		
n	ϕ	θ_n	F_n	ϕ	θ_n	F_n
−1	−0.2	0.50110	−0.01229	...	.....	.....
0	0.0	0.50000	0.00000	0.0	0.50000	0.00000
1	0.2	0.50093	0.00803	0.2	0.50093	0.00803
2	0.4	0.50298	0.01362	0.4	0.50311	0.01334
3	0.6	0.50606	0.01690	0.6	0.50615	0.01670
4	0.8	0.50958	0.01909	0.8	0.50972	0.01879
5	1.0	0.51353	0.02019	1.0	0.51362	0.01999
6	1.2	0.51759	0.02087	1.2	0.51769	0.02065
7	1.4	0.52180	0.02104	1.4	0.52185	0.02093
8	1.6	0.52598	0.02111	1.6	0.52604	0.02097
9	1.8	0.53020	0.02090	1.8	0.53022	0.02085
10	2.0	0.53434	0.02071	2.0	0.53437	0.02064

of Eq. (16) is obvious. Evaluation of the right side of Eq. (16) could be performed analytically. However, it is simpler to use Eq. (5) to determine numerically the time required to reach a specific temperature.

If it is desired to know the time required for the tank temperature to reach 150 F., use of Eq. (6) and the three points $\theta = 0.590$, 0.549 and 0.508 gives $\phi = 2.13$. If the interval between $\theta = 0.590$ and $\theta = 0.508$ is broken into ten intervals and Eq. (6) is applied to each pair of intervals such that

$$\int_{\theta^4}^{\theta_{10}} f(\theta)\,d\theta = \frac{\Delta\theta}{3}\,(f_o + 4f_1 + 2f_2 + 4f_3 + \cdots + f_{10}) \quad (17)$$

the value of ϕ is found to be 1.44. The analytical solution given by Eq. (13) with an average a indicates the value of $\phi = 1.31$ while an analytical solution assuming a linear variation of a determines $\phi = 1.41$.

From these results, we find that use of too large an interval in numerical integration may give large errors, but with reduction of the interval, the error in the answer may be made very small.

Ordinary Differential Equations

Equations given in the preceding section are sufficient to formulate some of the more common procedures for the numerical solution of ordinary differential equations. A first order differential equation of the form:

$$dy/dt = F(y, t) \quad (18)$$

where $F(y,t)$ is a known function of y and t and the initial condition is $y = y_o$ at $t = o$ may be numerically solved by an iterative process based on polynomial approximation.

Since polynomial interpolation and integration approximations are greatly simplified by the use of a constant interval size for the independent variable, it is convenient to re-define the independent variable such that $t = s\Delta t$ and $t_n = n\Delta t$ for the present problem. Similar notations are convenient for y and $F(y,t)$. Thus, y_n is understood to mean the value of y at $t = t_n$ and $F_n \equiv F\ (y_n, t_n)$.

After N values of y have been calculated a polynomial approximation of any order less than $(N - 1)$ may be evaluated for $F(y,t)$ by using Eq. (3). For example: if a second order approximation to $F(y,t)$ is used and y_{n-2}, y_{n-1} and y_n have been calculated, the following polynomial is one possible approximation for $F(y,t)$ near the points t_{n-2}, t_{n-1} and t_n.

$$F(s) = \frac{(s-n+1)(s-n)}{2}\,F_{n-2} - (s-n+2)(s-n)F_{n-1} + \frac{(s-n+2)(s-n+1)}{2}\,F_n \quad (19)$$

The original differential equation may then be used to find y_{n+1} by integration over the interval t_n to t_{n+1} or from $s = n$ to $s = (n + 1)$ by the relation

$$\int_{y_n}^{y_{n+1}} dy = \int_{t_n}^{t_{n+1}} F(y, t)\,dt \quad (20)$$

Use of Eqs. (19) and (20) give the approximate value of y_{n+1} as

$$y_{n+1} \cong y_n + \Delta t \int_n^{n+1} F(s)\,ds = y_n + \frac{\Delta t}{12}\,(23F_n - 16F_{n-1} + 5F_{n-2}) \quad (21)$$

It is apparent that after three values of y_n have been evaluated, Eq. (21) could be used to determine approximations for y at successive values of t.

Since the initial condition $y(0) = y_o$ gives only one value of y with which to start computation, two additional starting values of y must be obtained by some auxiliary method. Several auxiliary methods have been proposed. Some of these are discussed in Reference 2. A simple starting procedure is the use of a Taylor's series approximation about $t = 0$ to estimate y at $t = +\Delta t$ and at $t = -\Delta t$. The appropriate approximation is given by:

$$y_{+1} \cong y_o + \Delta t\left(\frac{dy}{dt}\right)_o + \frac{(\Delta t)^2}{2!}\left(\frac{d^2y}{dt^2}\right)_o + \frac{(\Delta t)^3}{3!}\left(\frac{d^3y}{dt^3}\right)_o + \cdots$$

$$y_{-1} \cong y_o - \Delta t\left(\frac{dy}{dt}\right)_o + \frac{(\Delta t)^2}{2!}\left(\frac{d^2y}{dt^2}\right)_o - \frac{(\Delta t)^3}{3!}\left(\frac{d^3y}{dt^3}\right)_o + \cdots \quad (22)$$

Eq. (18) may be used to determine dy/dt at time $t = 0$ in Eq. (22). Higher differentials of y at $t = 0$ may be calculated by successive differentiations of Eq. (18) and substitution for previously determined differentials of y at $t = 0$. For example:

$$\left(\frac{d^2y}{dt^2}\right)_o = \left(\frac{\partial F}{\partial t}\right)_o + \left(\frac{\partial F}{\partial y}\,\frac{dy}{dt}\right)_o \quad (23)$$

After y_{-1}, y_0 and y_1 are determined, Eq. (21) may be used as previously indicated to find y_2, y_3, etc.

The necessity for using auxiliary equations to start computation is troublesome and frequently can be very complicated if the function $F(y,t)$ is irrational or if the Taylor's seris about $t = 0$ converges very slowly. A few methods have been proposed to avoid the use of starting relations. The most popular of these self-starting methods is the Runge-Kutta method which is discussed in Ref. 2.

The numerical method for the solution to ordinary differential equations already described is classified as an open method. The reason for this classification is that the iterative process uses only previously calculated values of the dependent variable to determine

Approximating Methods—Table II

Method	Order of Approximation	Increment	Results in Table III, Col.
Open, Eq. (21)	Second, 3 point	0.2	A
Closed, Eq. (25)	Second, 3 point	0.2	B
Open	First, 2 point	0.2	C
Closed	First, 2 point	0.2	D
Euler's	Zero, 1 point	0.2	E
Open, Eq. (21)	Second, 3 point	0.4	F
Closed, Eq. (25)	Second, 3 point	0.4	G
Open	First, 2 point	0.4	H
Closed	First, 2 point	0.4	I
Euler's	Zero, 1 point	0.4	J

the next value of the dependent variable. One disadvantage of the open method is the tendency for errors to build up during the iteration.

Try Closed Method For Numerical Analysis

Rate of increase of errors can frequently be reduced by using a closed method for numerical solution. An example of a closed formula for numerical integration can be derived by starting with Eq. (3) as the polynomial approximation for $F(y,t)$ using F_{n-1}, F_n and F_{n+1}.

$$F(s) = \tfrac{1}{2}(s-n)(s-n-1)F_{n-1} - (s-n+1)(s-n-1)F_n + \tfrac{1}{2}(s-n+1)(s-n)F_{n+1} \quad (24)$$

Eq. (20) may again be used to solve for y_{n+1} with the result:

$$y_{n+1} \cong y_n + \frac{\Delta t}{12}(5F_{n+1} + 8F_n - F_{n-1}) \quad (25)$$

Since Eq. (25) contains F_{n+1} which usually depends on y_{n+1}, the solution of Eq. (25) for y_{n+1} after y_n and y_{n-1} are calculated will frequently require a trial and error process. However, if F is a linear function of y, Eq. (25) could be solved for y_{n+1} without the necessity of a trial and error procedure. In the latter case, F_{n+1} can be expressed as:

$$F_{n+1} = a_{n+1}y_{n+1} + b_{n+1} \quad (26)$$

where a_{n+1} and b_{n+1} are either constants or depend only on t.

Introducing Eq. (26) into Eq. (25) and solving for y_{n+1}, we find

$$y_{n+1} = \frac{y_n + \frac{\Delta t}{12}(5b_{n+1} + 8F_n - F_{n-1})}{1 - \frac{5\Delta t}{12}(a_{n+1})} \quad (27)$$

Since y_n, b_{n+1}, F_n, F_{n-1} and a_{n+1} are known, y_{n+1} can be found directly. If F is nonlinear in y, a similar procedure may be used but will require some iteration. Where F is nonlinear in y, we may define parameters similar to a_{n+1} and b_{n+1} such that a Newton's approximation is utilized. If we assume

$$F_{n+1} \cong F_{n+1}{}^i + \left(\frac{\partial F}{\partial y}\right)_y (y_{n+1} - y_{n+1}{}^i)$$

where subscript $y = y_{n+1}{}^i$, t_{n+1} and i refers to the value of a quantity determined after i iterations in the solution of Eq. (27), we may use the approximation:

$$F_{n+1} \cong a_{n+1}{}^i y_{n+1} + b_{n+1}{}^i \quad (28)$$
$$a_{n+1}{}^i = (\partial F/\partial y)_y$$
$$b_{n+1}{}^i = F_{n+1}{}^i - a_{n+1}{}^i y_{n+1}{}^i$$

A simple example of a closed integration equation may be found using only the two points t_n and t_{n+1} to determine a linear approximation for F over the interval of integration.

$$dy/dt \cong \tfrac{1}{2}(F_n + F_{n+1}) \quad (29)$$

Upon integration, Eq. (28) yields:

$$y_{n+1} \cong y_n + \tfrac{1}{2}(F_n + F_{n+1})\,\Delta t \quad (30)$$

Use of Eq. (26) or (28) for F_{n+1} finally gives

$$y_{n+1} \cong \frac{y_n + \frac{1}{2}(F_n + b_{n+1})\,\Delta t}{1 - \frac{1}{2}(a_{n+1}\,\Delta t)} \quad (31)$$

Solve Example by Numerical Method

Using the previous problem, we will now illustrate the numerical solution of an ordinary differential equation. If the inlet temperature to the heater is held constant, while the inlet feed rate varies as a function of time, the differential energy balance is still valid. However, it is no longer separable and cannot be solved by direct integration.

To obtain the differential energy balance, start with Eq. (11) and use the dimensionless parameters:

$$d\phi = m_i{}^\circ\,dt/M_\circ, \quad \alpha = UA/m_i{}^\circ c_p, \quad \theta = (T - T_\circ)/(T_i - T_\circ)$$

Hence, Eq. (11) now gives:

$$\frac{M}{M^\circ}\frac{d\theta}{d\phi} = -\alpha\theta + \frac{m_i}{m_i{}^\circ}(1-\theta) \quad (32)$$

where $m_i{}^\circ$ is the feed rate at $t = 0$ and m° is the initial mass of liquid in the tank.

A differential mass balance for the system is readily found to be:

$$\frac{d(M/M^\circ)}{d\phi} = \frac{m_i - m_\circ}{m_i{}^\circ} \quad (33)$$

If we consider the case where m_i varies linearly with time, starting with the value $m_i{}^\circ$ and m° is kept equal to m_i by suitable control, Eq. (33) becomes superfluous and Eq. (32) reduces to

$$\frac{d\theta}{d\phi} = -(\alpha + 1 + a\phi)\theta + 1 + a\phi \quad (34)$$

where a is a constant defined such that

$$m_i/m_\circ = 1 + a\phi \quad (35)$$

Eq. (34) is exactly of the same form as Eq. (18) with

$$F(\theta, \phi) = -(\alpha + 1 + a\phi)\theta + 1 + a\phi \quad (36)$$

If the inlet temperature T_i is 68 F., steam temperature T_s is 212 F. and the data on p. 214 again describe the variation of a with T, an interpolation polynomial for a as a function of θ is:

$$\alpha = 0.12\theta^2 + 0.08\theta + 0.93 \quad (37)$$

If the tank is initially in a steady state condition at ϕ equals zero, θ equals 0.5. Thus, Eqs. (34) and (37) with the initial condition $\theta_c = 0.5$ are sufficient to describe the temperature variation with ϕ for any specific value of the constant a.

A numerical solution using either the open formula Eq. (21) or the closed formula Eq. (25) requires the

Numerical Methods Give Different Temperature Variations—Table III

Increment ϕ	A Open 3 Pt.	B Closed 3 Pt.	C Closed 2 Pt.	D Closed 2 Pt.	E Euler's	F Open 3 Pt.	G Closed 3 Pt.	H Open 2 Pt.	I Closed 2 Pt.	J Euler's
0.0	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000	0.50000
0.2	0.50093	0.50093	0.50093	0.50082	0.50000					
0.4	0.50298	0.50311	0.50334	0.50300	0.50200	0.50355	0.50355	0.50355	0.50280	0.50000
0.6	0.50606	0.50615	0.50639	0.50605	0.50514					
0.8	0.50958	0.50972	0.50996	0.50964	0.50892	0.50804	0.50992	0.51099	0.50946	0.50800
1.0	0.51353	0.51362	0.51382	0.51355	0.51303					
1.2	0.51759	0.51769	0.51786	0.51764	0.51729	0.51865	0.51780	0.51811	0.51753	0.51702
1.4	0.52180	0.52185	0.52199	0.52182	0.52160					
1.6	0.52598	0.52604	0.52615	0.52602	0.52590	0.52293	0.52610	0.52673	0.52596	0.52588
1.8	0.53020	0.53022	0.53031	0.53021	0.53016					
2.0	0.53434	0.53437	0.53443	0.53436	0.53436	0.53830	0.53440	0.53443	0.53433	0.53441

In columns A through E, increment $\Delta\phi$ is 0.2 and in columns F through G, $\Delta\phi$ is 0.4

determination of additional values of θ near the time zero. Use of the Taylor's series approximation given by Eq. (22) is the method chosen to illustrate the use of these numerical techniques.

The initial first derivative of θ can be found from Eq. (34) and is equal to zero because the tank is initially in a steady state condition. Taking the derivative of both sides of Eq. (34), we find:

$$\frac{d^2\theta}{d\phi^2} = -\left(\frac{d\alpha}{d\theta}\frac{d\theta}{d\phi} + a\right)\theta - (\alpha + 1 + a\phi)\frac{d\theta}{d\phi} + a \quad (38)$$

At $\phi = 0$, $d\theta/d\phi = 0$ and Eq. (38) becomes:

$$\left(\frac{d^2\theta}{d\phi^2}\right)_0 = a(1 - \theta_0) = 0.5a \quad (39)$$

A second differentiation gives:

$$\frac{d^3\theta}{d\phi^3} = -1.05a \quad (40)$$

A third differentiation gives:

$$\frac{d^4\theta}{d\phi^4} = 2.205a - 1.5a^2 \quad (41)$$

For $a = 0.10$, the Taylor's series expansion of θ about $\phi = 0$ gives:

$$\theta(\Delta\phi) \cong 0.5 + \frac{(\Delta\phi)^2}{2} \times 0.05 - \frac{(\Delta\phi)^3}{6} \times 0.105 + \frac{(\Delta\phi)^4}{24} \times 0.2055 \quad (42)$$

$$\theta(-\Delta\phi) \cong 0.5 + \frac{(\Delta\phi)^2}{2} \times 0.05 + \frac{(\Delta\phi)^3}{6} \times 0.105 + \frac{(\Delta\phi)^4}{24} \times 0.2055$$

Choosing first an interval size $\Delta\phi = 0.2$ gives:

$$\theta(0.2) \cong 0.50093 \quad \text{and} \quad \theta(-0.2) \cong 0.50110 \quad (43)$$

After approximate values of θ at ϕ_{-1}, 0 and ϕ_1 are determined, $F(\theta\ \phi\ )$ at these same points may also be calculated using Eq. (36). Then Eq. (21) may be used to calculate the approximate value of θ at $\phi = 2\Delta\phi$ and the process repeated any number of times. The left half of Table I shows the result of using Eq. (21) to evaluate θ at intervals of ϕ up to $\phi = 2$.

A similar approach may be used with Eq. (25) for the evaluation of θ_{n+1} after θ_n, F_{n-1} and F_n are determined. Either a straight trial and error procedure involving the estimation of θ_{n+1} to calculate F_{n+1} and then a check on the estimation and repitition is necessary or the iterative process summarized in Eq. (28) may be used in the calculation. The right half of Table I shows the results of using Eq. (25) to evaluate θ.

A problem of considerable interest to engineers who are faced with calculations of very complicated problems is the determination of the minimum steps which are necessary to insure reasonable accuracy. This problem is a difficult one to answer because of the variety of equations and approximations which might be chosen and the difficulties involved in estimating errors. A limited comparison of the accuracy of open and closed methods is given by Tables III and V.

Reduction of the order of the approximation and enlargement of the interval size reduce the number of calculations required for numerical solution of a differential equation. Several orders of approximations for $F(s)$ and two different time increments were used with open and closed methods. The different methods and increments used to calculate θ as a function of ϕ for the problem are given in Table II. Results of the calculations are shown in Table III.

Euler's method is the simplest of the approximations and is based on the assumption that $F(\theta, \phi)$ changes only slightly over each interval and, therefore, may be

Numerical Methods—Table IV

Euler

$\theta_{n+1} \cong \theta_n + F_n\,\Delta\phi$

Open, first order

$\theta_{n+1} \cong \theta_n + (\Delta\phi/2)(3F_n - F_{n-1})$

Open, second order

$\theta_{n+1} \cong \theta_n + (\Delta\phi/12)(23F_n - 16F_{n-1} + 5F_{n-2})$

Closed, first order

$\theta_{n+1} \cong \theta_n + (\Delta\phi/2)(F_n + F_{n+1})$

Closed, second order

$\theta_{n+1} \cong \theta_n + (\Delta\phi/12)(5F_{n+1} + 8F_n - F_{n-1})$

Compare Errors for Each of the Numerical Methods—Table V

Increment	Open	Closed	Open	Closed	Euler's	Open	Closed	Open	Closed	Euler's
ϕ	A	B	C	D	E	F	G	H	I	J
0	0	0	0	0	0	0	0	0	0	0
0.2	5	5	5	−6	−93					
0.4	−8	5	28	−6	−106	49	49	49	−26	−329
0.6	−5	4	28	−6	−97					
0.8	−11	3	27	−5	−77	−165	23	130	−23	−169
1.0	−6	3	23	−4	−56					
1.2	−8	2	19	−3	−38	98	13	44	−18	−65
1.4	−4	1	15	−2	−24					
1.6	−6	0	11	−2	−14	−311	6	69	−8	−16
1.8	−2	0	8	−1	−6					
2.0	−3	0	6	−1	−1	393	3	6	−4	4

Multiply each error value by 10^{-5}.

assumed constant. Euler's formula for integration is:

$$\theta_{n+1} \cong \theta_n + F_n \Delta\phi \qquad (44)$$

The closed method with a first order approximation is frequently referred to as a modified Euler's method since the average slope at the beginning and end of each interval is used to estimate the change in the dependent variable. Equations used for the different approximations are given in Table IV.

Compare the Different Methods

To compare the results of the different methods reported in Table III, one further set of calculations were made with a second-order closed method using $\Delta\phi = 0.1$. The differences between the values obtained by each of the methods are shown in Table V. An inspection of Table V indicates the following:

1. Closed methods tend to be more consistent than open methods. Errors in the results from the use of closed formulas tend to be of uniform sign and to decay rapidly in this example.
2. Use of a smaller interval with the closed formulas reduces the error by factors of from 4 to 10.
3. Too large an interval used with the open equation can lead to very large errors which tend to grow in size as the computation continues.
4. Euler's equation can lead to appreciable errors which are reduced in size by only a factor of two on halving the interval size.

It should be emphasized that Table V at best gives only the results for the solution of one particular problem and generalizations from this example might not be valid. However, this example is typical of many problems which arise in unsteady state heat transfer.

Errors in Approximations

Major difficulty in the use of the Lagrangian form for the polynomial approximation Eq. (1) is the determination of errors inherent in the case of the approximation. For functions based on experimental data or other nonanalytical functions with values known only at specific points of the independent variable, error estimates must be based on additional points not used in the determination of the approximate function.

Error estimates are usually derived from examinations of the magnitude and variations in the divided differences of the function. For analytical functions, error estimates may be based on relations which employ the knowledge of the magnitude of the higher derivatives of the function. Derivation of error estimates for approximations to analytical functions follows directly from a Taylor's series expansion. A discussion of this derivation may be found in References 2, 3 and 5. Once the errors in the polynomial approximations are determined, error estimates may be found for the integral or derivative of the polynomial compared to the corresponding values of the actual function.

Errors introduced by the substitution of an approximate function for an unknown or complicated one are generally termed truncation errors, since theoretically a function which is continuous and has continuous derivatives could be represented exactly by an infinite series and any approximation is only a finite part of the truncated series.

Further errors which may arise because of inaccurate experimental data or the use of a model approximation must be taken into account separately and estimated from additional information. Such additional errors may be magnified considerably during the numerical solution of a problem.

Most error estimates start with the assumption that the values of the function used to determine the polynomial approximation are known exactly. In the iterative solution of a differential equation, only approximate values are known. Thus, the errors introduced at each step of the calculation affect the answers obtained in all later steps of the iteration. The determination of the rates of growth of these errors may be attacked by solutions of finite difference equations. A discussion of this problem is also included in Ref. 2.

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Graphical Method Aids . . .

Constant Rate Filtration Scaleup

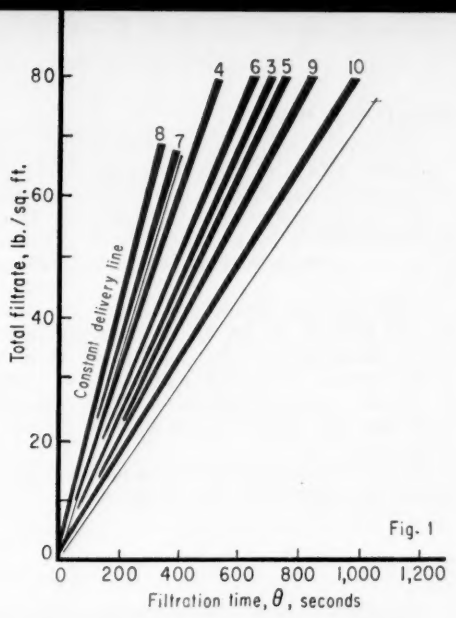


Fig. 1

Design of constant rate filtration equipment usually requires scaleup from laboratory data. An improved graphical method obviates the difficulties ordinarily encountered in doing this.

G. EDWIN WHITE* and SEYMOUR C. HYMAN† Department of Chemical Engineering, The City College, New York, N. Y.

Methods previously in use for handling the data from constant rate filtration experiments in the laboratory have been difficult to use and often involve inaccuracies of extrapolation of curves or trial-and-error procedures. An improved graphical method developed by the late Prof. G. Edwin White and presented to his classes in the Unit Operations is described here as Prof. White desired. This method reduces the data to a case of equivalent constant pressure.

When a slurry is fed to a filter at a constant volumetric flow rate, the process is called constant rate filtration. Since the resistance to filtrate flow increases as the cake deposits in increasing thickness, fluid pressure at the entrance of the filter must increase continuously to maintain the flow constant. This is in contrast to the mode of operation in which the filter inlet pressure is held constant while the flow rate diminishes. Constant rate filtration is used industrially, either alone or in combination with constant pressure filtration.

The design of filtration equipment is based on the characteristics of the cake formed during the operation. Usually these characteristics are determined from laboratory tests on sample slurries. Also, cake properties seem to be influenced by the way the cake is formed. All of which shows that the design of constant rate filtration equipment should be based on the scaleup of constant rate data secured in the laboratory.

Briefly looking at the theoretical background, starting with Poisseuille's equation for the flow through porous solids, we can derive the equation

$$\frac{dW}{d\theta} = \frac{1}{2fP^{s-1}W + gP^{m-1}} \qquad (1)$$

For constant rate filtration

$$\frac{W}{\theta} = \frac{dW}{d\theta} \qquad (2)$$

so the time of filtration of a quantity W is

$$\theta = 2fP^{s-1}W^2 + gP^{m-1}W \qquad (3)$$

The constant rate of filtration (or its reciprocal) is

$$\frac{1}{Q} = \frac{\theta}{W} = 2fP^{s-1}W + gP^{m-1} \qquad (4)$$

Taking the case of constant rate filtration, Figs. 1 and 2 record the data for filtration of a 2½%-by-weight water slurry of calcium carbonate. A Shriver plate-and-frame washing-type filter press of about 1 sq. ft. area was supplied at eight constant rates with slurry by a Goulds Triplex constant-displacement pump driven through a Reeves variable-speed drive. For each delivery rate the data included filtrate volume, time and filter inlet pressure.

Since the body of data in Fig. 2 is from a single press and slurry, then isobars drawn on the chart

Nomenclature

$2f$	$\nu r' (1 - s)e$.
g	$r'' \nu$.
m	"Plugging number," exponent in Eq. (1).
P	Gage pressure at filter inlet.
Q	Filtration rate per unit area and unit time.
r'	Constant contained in f.
r''	Constant contained in g.
s	"Compressibility number," exponent in Eq. (1).
W	Total filtrate volume per unit area.
ν	Kinematic viscosity of filtrate.
θ	Time.

* Deceased; formerly Chairman, Dept. of Chemical Engineering.
† Assistant Dean, School of Technology, The City College.

intersect points of identical cake and press characteristics and pressure. These values are the total filtrate obtained by proceding to a given pressure at various constant rates.

From Eq. (4) it appears that a plot of θ/W vs. W for all the data points found on an isobar on Fig. 2 would form a straight line of slope $= 2\ f\ P^{s-1}$ and intercept $= g\ P^{m-1}$. This has been done for five of the isobars on Fig. 3.

Now, if the slopes and the intercepts are plotted vs. the pressure on log paper, one can evaluate the constants f, s, g and m.

This provides the analytical expression for extrapolation to plant-scale equipment, calculations of optimum cycles, etc. In this case the values obtained for these data were: $f = 0.82$; $s = 0.26$; $g = 85$; and $m = 0.16$.

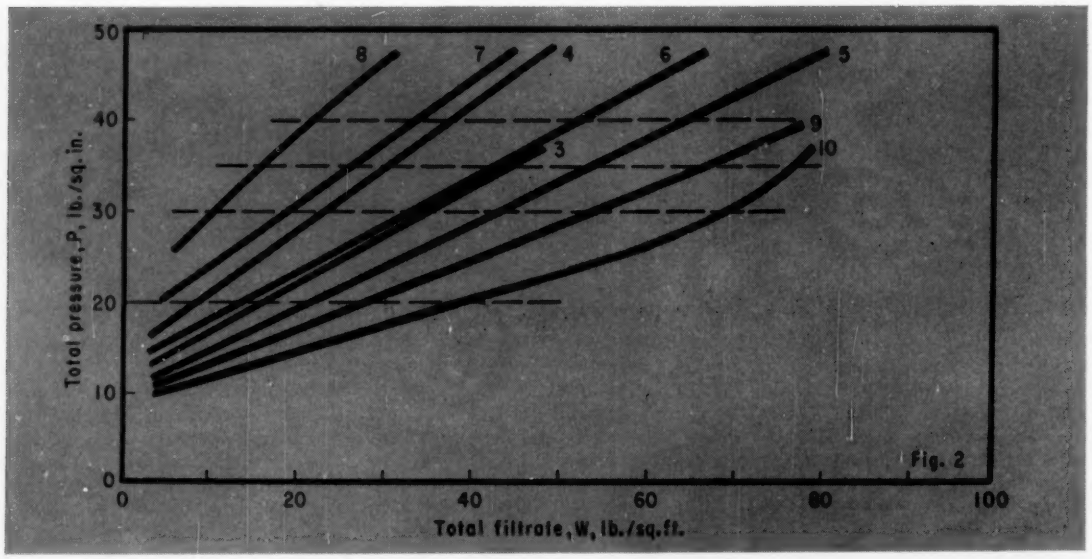
Taking the case of constant pressure filtration, integrating Eq. (1) gives

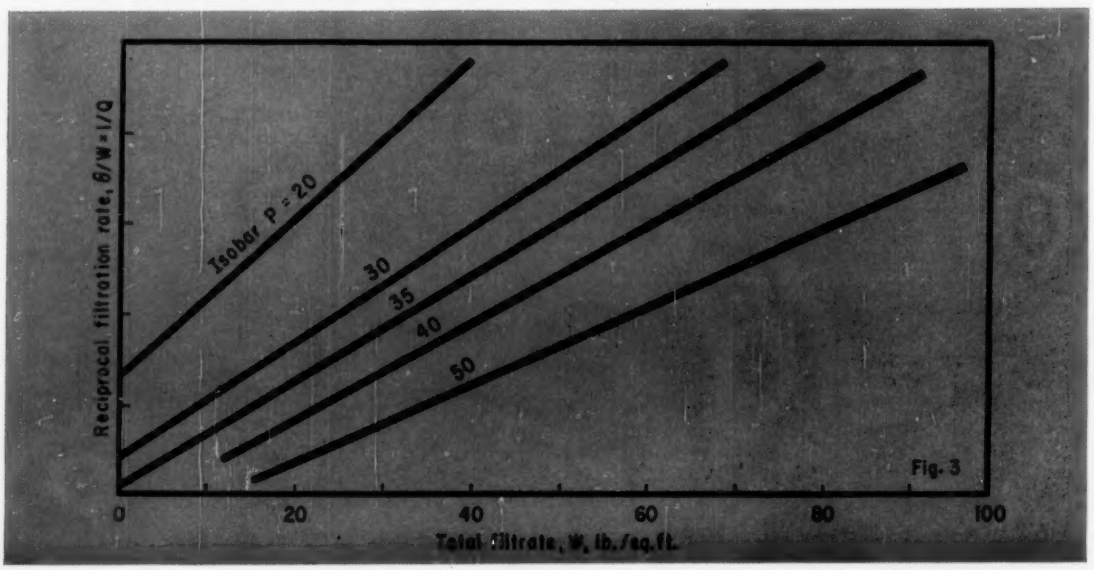
$$\theta = fP^{s-1}W^2 + gP^{m-1}W \qquad (5)$$

Since each set of data at constant pressure represents an "isobar," each set can be plotted at once as the following:

$$\frac{\theta}{W} = fP^{s-1}W + gP^{m-1} \qquad (6)$$

to give a straight line. The slopes and intercepts on log plots vs. the pressure will, as before, yield the constants of the equation. However, in this case one must make sure that the data all apply to the constant pressure period and do not include buildup time.





4,759 Chemical Engineers in the National Register*
Report a Median Annual Salary (1956-1958 Data) of . . .

$10,436 The group breakdown looks like this:

Field and Type of Employer		By Highest Degree	
Education	$ 8,728	Less than a master's	$ 9,818
Federal government	$ 9,523	With a master's degree	$ 9,932
Nonprofit organizations	$ 9,682	With a doctorate degree	$11,637
Industry or self-employed	$10,442		

Function or Work Activity		By Age Groups	
All managers	$14,048	20 to 29	$ 6,895
Managers of res. & dev.	$13,936	30 to 39	$ 9,583
Research, dev. or design	$ 8,957	40 to 49	$12,792
Teaching	$ 8,329	50 to 59	$15,184
All other functions	$ 9,734	60 or over	$14,608

*National Register of Scientific and Technical Personnel

Chemical Engineers: $125,232 per Dozen

Figures don't lie. But the latest statistics from the National Register of Scientific and Technical Personnel are bound to confuse wage and salary administrators.

Are you estimating the cost of staffing a new chemical process plant with a dozen chemical engineers of assorted experience and competence? You won't be far wrong if you budget your total payroll at $125,232/yr.

Are you responsible for administering the salaries of chemical engineers? It should be an easy job because chemical engineers without master's degrees are already earning more than scientists who hold the doctor of philosophy degree.

Are you helping to guide young people—your own son, perhaps—into life-long careers? Recommend that they select chemical engineering since (except for medical doctors) chemical engineering is the highest paid scientific or technical skill.

Where do these conclusions come from?

They are based upon a very reliable source. They come bearing the official stamp of the Government of the United States of America via a report released

about a month ago by the National Science Foundation.

Many of you have already seen this report. It was included with the questionnaire form for the 1960 National Register of Scientific and Technical Personnel. Dated April 1960 and identified as NSF 60-22, the report profiles the salaries reported by scientists and engineers in the 1956-1958 Register.

For those of you who have not seen the original of this report, we've highlighted some of the figures for chemical engineers in the box on the previous page.

► **Watch Out, Go Easy**—Many chemical engineers have often told *CE* that there can never be enough information published on salaries. Wage and salary administrators at several large chemical companies have expressed the opinion that there is already too much in print about salaries.

A sampling of comments on this latest information brings an almost unanimous wish that it never had been published. Unless you take the time to read all the fine print and understand the limitations that must be associated with drawing any sort of conclusions from it, you can very easily be trapped into deciding that chemical engineers are among the richest and most satisfied of all technically trained people.

Here are some of the major pitfalls:

- The data are at least three years old, and in many cases five years old.
- The sample is extremely poor, almost haphazard. "The standards for inclusion in the National Register varied somewhat from one scientific field to another."
- Only 4,759 chemical engineers (members of professional societies, or considered to be professional by the societies) were included out of at least 50,000 available.
- It is generally agreed that one of the least reliable methods of conducting a salary survey is to ask individuals to report their own incomes. They often report inflated, false amounts in order to raise the curve.

This report from the National Science Foundation is destined to disillusion chemical engineers and confuse those who administer chemical engineering salaries. We therefore call it to your attention, but recommend that it be used with extreme caution.

Questionnaire on Safeguarding Trade Secrets

Questions	Answers: Yes Replies	Yes %	No Replies	No %
1. At the time of the employment interview, do you specifically discuss with an engineer the areas of information gained in prior employment that he may properly make available to you?	91	44	115	56
2. Are your company's trade secrets, or developments which may lead to trade secrets, defined for engineering employee guidance at any time during employment?	112	54	94	46
3. Is a definition of restricted company information reviewed with the employee at termination to ensure that a clear understanding exists for limitation of future disclosures?	65	32	141	68
4. Does the company use contracts with engineering employees to restrict use of company-acquired knowledge either during or after the term of employment?	99	48	107	52

A Two-Year Follow-Up Report on . . .

Does Your Employer Own Your Knowledge?

Recent legal battles have focused the attention of the engineering profession on employer-employee contractual relationships as they concern transmittal and use of engineering knowledge, especially in the area of proprietary information and trade secrets.

In 1958, *CE* published a pioneering article on this controversial subject, summarizing the content of the legal issues involved and reporting some of the important court decisions that are now a matter of public record (*Chem. Eng.*, July 28, 1958, pp. 127–130).

Shortly thereafter Engineers Joint Council decided that a service could be rendered to the

News from
National Carbon Company
Division of Union Carbide Corporation · 270 Park Avenue, New York 17, New York
In Canada: Union Carbide Canada Limited, Toronto

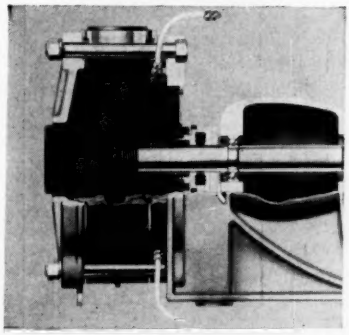
National Carbon Design Engineers expand your engineering force

J. A. MRAZ
Design Engineer

Mr. Mraz was graduated from Fenn College in 1953 with a B. S. in Chemical Engineering. He joined National Carbon Company the same year and spent the following two years in the sales engineering department. Here he designed carbon, graphite and "Karbate" impervious graphite chemical process equipment.

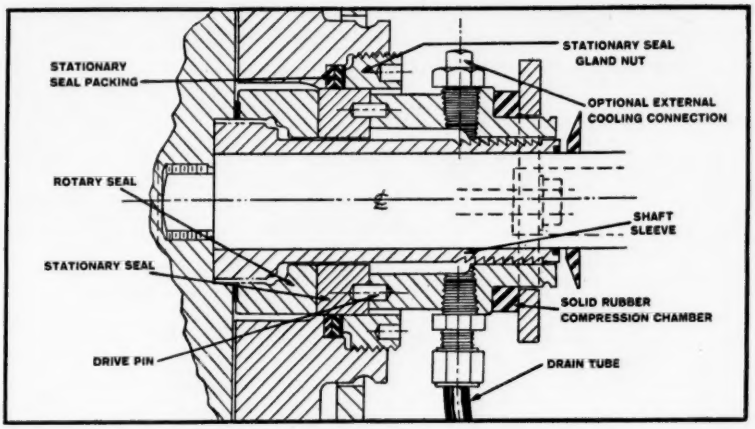
Jim's been specializing, for the past five years, in the thermal design and development of "Karbate" impervious graphite heat transfer equipment.

Seal cooling water connection modified on "Karbate" Model CA centrifugal pumps



This new seal cooling water design offers a stronger connection because it is made through the "Karbate" impervious graphite case cover. This eliminates placing stresses on the plastic water retaining shield which previously held the water connection. With the new arrangement, water flows directly on the rotary seal, thereby assuring complete cooling. Water is drained from the case seal cavity through a drain connection which is attached to the "Karbate" case cover.

REDESIGNED SEAL ARRANGEMENT ON "KARBATE" TYPE F MOTOR-MOUNTED PUMPS IMPROVES OVERALL OPERATION



NATIONAL CARBON presently is supplying the type F centrifugal pump with a new rotary seal arrangement designated as model series FBL which replaces series FAL. The redesigned seal eliminates all but one metal part and provides simple adjustment for stationary seal packing and seal setting. The adjustments can be performed while the pump is in operation. To provide protection against corrosion, the seal is designed to keep any leakage from contacting metal parts of the pump. If desired, the seal arrangement can be easily adapted for external water cooling. For additional data, write for **Catalog Section S-7253 CJ.**

"Karbate" centrifugal pumps can be belt-driven to obtain high heads and flows

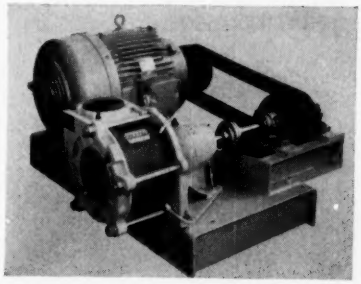


Illustration shows a belt-driven assembly of a "Karbate" type C Model 4CA-10 pump which will handle 1,000 GPM of Cl_2 saturated NaCl brine against a total dynamic head of 120′ of brine. The power source is a 60 hp, 1750 rpm motor with a V-belt arrangement which permits operation at 1920 rpm. This is accomplished by utilizing six V-belts on an 11″ pitch dia. driver sheave to a 10″ pitch dia. pump sheave.

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NATIONAL CARBON COMPANY
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engineering profession by studying this problem, and assigned the task to its Committee on Employment Conditions. Single copies of the committee's final report are now available without charge from Leroy K. Wheelock, Executive Secretary, EJC, 29 West 39th St., New York 18.

▶**The Individual Decides** — After analyzing the 206 responses to its questionnaire (800 engineering employers were invited to participate) EJC comes up with this major conclusion:

"The engineer generally is expected to determine for himself what information gained on one job he may utilize on a subsequent job—bearing in mind that he or his new employer may later be held legally accountable."

In the exploration of prior know-how, two-thirds of the employers indicated by their comments that they recognized the existence of a mutual problem in safeguarding prior confidential information.

Only a few of these, however, assumed any responsibilty to determine prior employee commitments or establish any framework whereby employee's knowledge could remain confidential. 80% of the comments assigned responsibility mainly or entirely to the new employees as individual members of the engineering profession.

Other details of the response pattern are given in the panel on the previous page.

▶**Selected Excerpts**—Here are some selected comments which were returned to the committee specifically on the subject of trade secrets:

- The obvious fact must be faced that in many cases an engineer is hired for a new job because of his experience on previous jobs. We have found no perfect way of spelling out what a man may disclose as part of his engineering skill distinguished from specific knowledge that may or may not have been confidential information on a previous job.
- As a practical matter we have found that lasting protection can be given to this sort of thing only by establishing a patent position on the subject.
- We rely primarily on the ethics and honesty of the individual.
- As long as there are no legal entanglements, we would logically expect to cash in on their experience.
- We do not expect to make use of knowledge of a secretive nature which employees acquired at other employment. We expect a gentlemen's agreement in reverse when the engineering employee decides to leave our organization.
- There is little that can be done to prevent an individual from using the know-how acquired with us after being hired by a competitor. Obviously, his value to either us or the competitor is based on his accumulated knowledge and total experience.

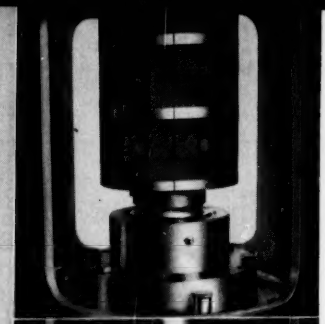
Chemical Engineer Is New Vice President of EJC

George E. Holbrook, a vice president, director and executive committee member of E. I. du Pont de Nemours & Co., has been elected vice president of Engineers Joint Council (EJC). A federation of 20 national engineering societies, EJC now represents more than 300,000 of the nation's engineers. Holbrook is a past president of AIChE and has served as a member of EJC's board of directors, executive committee and planning committee.

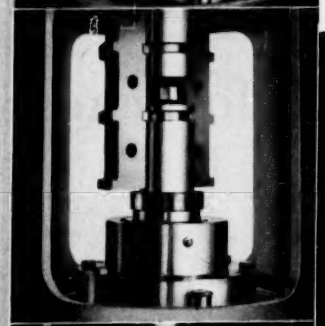
He is a graduate of the Univ. of Michigan, with a master of science degree in 1932 and a doctorate degree in 1933, all in chemical engineering.

SIMPLY DO THIS!

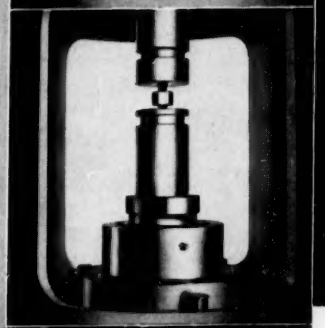
One easily assembled, self-aligning split sleeve coupling connects drive shaft and stirrer shaft.



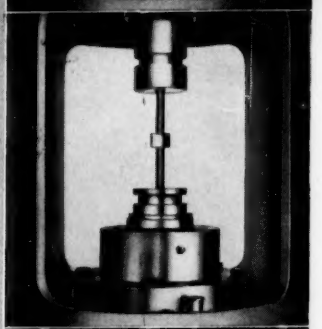
❶ Release sleeve collar set screws. Remove ½ of split sleeve coupling.



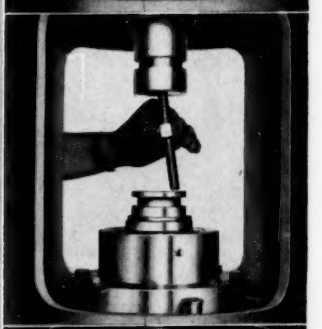
❷ Relieve shaft weight and remove remaining coupling half.



❸ Lower shaft on to support.



❹ Remove adjusting screw from opening.



❺ Unbolt and remove seal assembly. Reverse procedure to replace seal!

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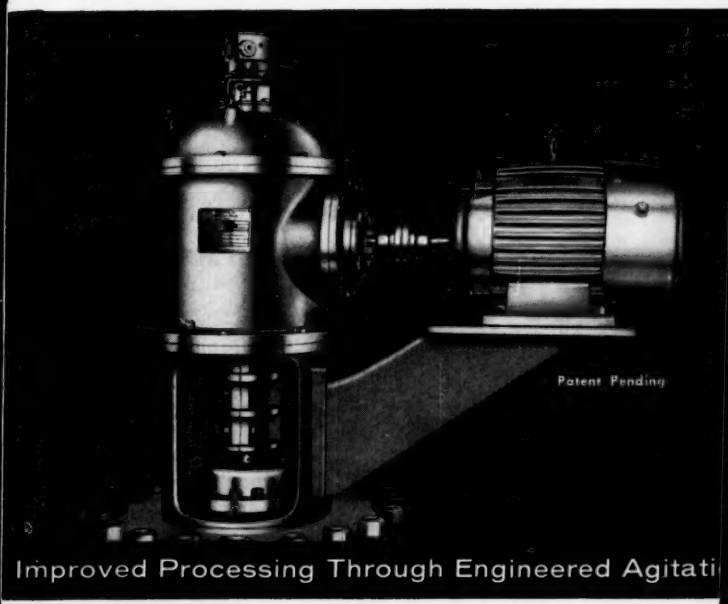

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Screens Improve Filter Performance

Nonclogging long-lived perforated metal screens economically replace cloth as support for filter paper in plate-and-frame filters.

C. WILLIAM BOYER, Atlas Powder Co., and CLARENCE E. AVERY, JR., Eaton-Dikeman Co.

In a plate-and-frame filter press, some type of filter medium does the actual filtration—the plate and frame assembly serves only to support the filter medium and contain the filtered solids.

Since the early days of filter presses, the filter medium was cloth. In more recent times, paper has begun to replace the cloth as the direct surface where the cake formed, but the cloth remains beneath the paper to support this relatively weak material.

Thus filter paper has altered the original function of the cloth —once a filter medium, now a supporting agent.

▶ **Disadvantages of Cloth** — Batch processes, though well adapted to manufacture of hundreds of various products, make filtration demands on cloth which are often expensive and impractical. For instance, a complete set of clean cloths had to be installed whenever there was a product changeover. Also, many products, such as waxes, could not be washed from the cloth.

In addition to these two problems, here are some other disadvantages of cloth filter media that we have encountered.

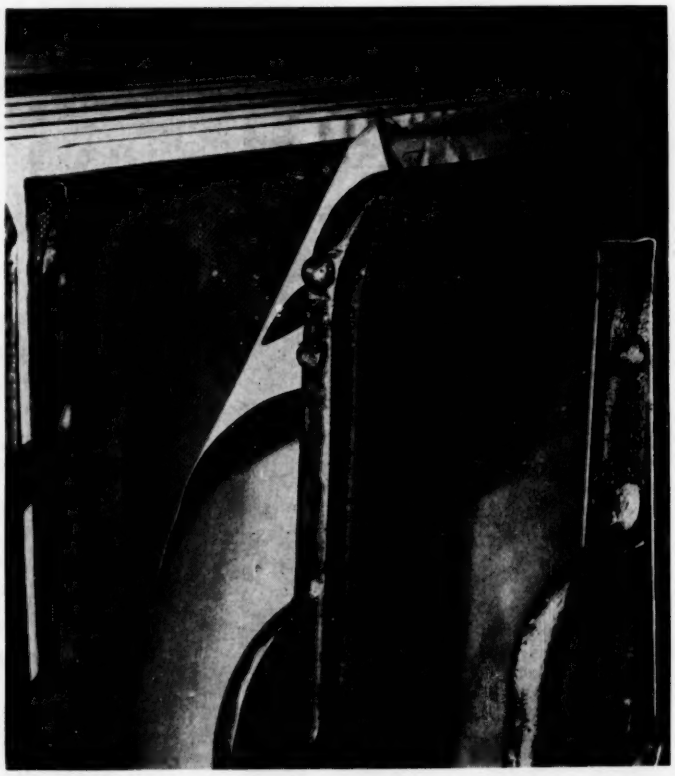
• Porosity of the cloth gradually decreased to the point where resistance became excessive. Thus the same cloth never gave the same results twice.

• After the initial pass through a new set of cloths, gradual wear and stretching allowed the cloth to press into the drainage areas of the filter plate itself. This restricted the drainage passage ways and increased the filtration pressure.

• Manpower, paper work and inventory control of cloths contributed to over-all plant expense.

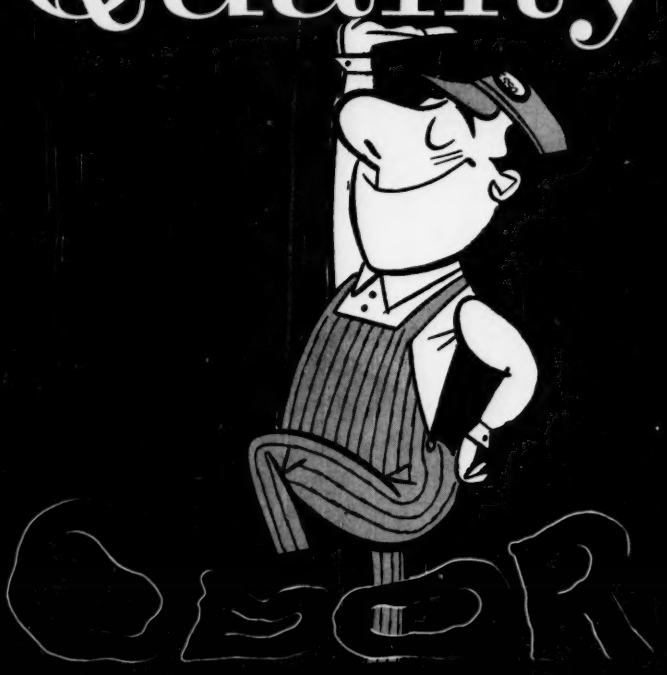
• Excessive downtime limited the operating cycle.

Though filter paper instead of cloth as the filter medium alleviates



PERFORATED metal sheets slip over plates in filter press to form a firm support for the actual filter medium, disposable filter paper.

Quality



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ated these problems to some extent, it could not eliminate them so long as cloth formed the support for the paper. Filling of the cloth, wear and stretching continued though at a slower pace.

So we looked around for something better than cloth to support the filter paper in our filter presses.

▶ **Perforated Sheets** — Perforated metal has been used on filtration equipment for over fifty years, but was seldom applied to plate-and-frame filter presses. Performance data were practically unavailable for this type of service.

We felt, however, that perforated metal sheets should offer all the advantages of cloth as support for filter paper without the disadvantages. Therefore, we ran an experimental filtration with perforated metal plates supporting the filter paper. Initial results were so good, we found it feasible to run economic studies on every filter unit in the plant.

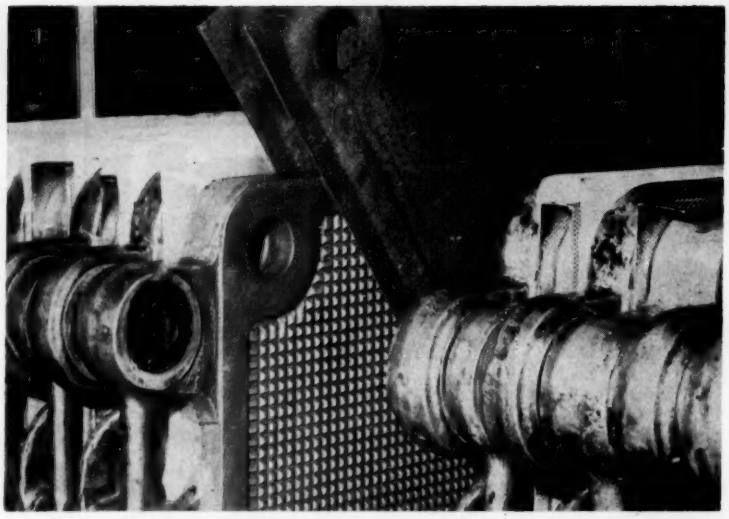
▶ **Some Case Histories** — We fitted a 24 in. filter press, which had 208 sq. ft. of press area, with perforated aluminum sheets having the following specifications:

20 gage (0.032 in. thick)
0.055 in. diameter perforations
$\frac{3}{32}$ in. regular staggered centers
95 holes/sq. in.
44% open area

The press was dressed with 15-lb. paper over the perforated sheets (see illustrations).

We filtered all products at average temperatures of 190 F. and pressures ranging from 40 to 60 psig. After five months during which approximately 300,000 gal. were filtered, the perforated plates showed signs of grooving and channeling caused by thermal stresses in the plates.

Press, plates and frames are made of commercial aluminum. At the start of filtration the perforated sheets are immediately heated by the slurry. Because of their light weight, they heat faster and expand more rapidly than the heavier metal parts of the press. The sheets must expand, but being tightly held in place, they tended to groove or channel. Eventually this grooving caused paper breakage.



ANOTHER view shows perforated sheet and filter plate more clearly.

We concluded that 20-gage material with 44% open area was not strong enough.

▶ **Strength Problem Solved**—To increase the life span of the sheets, we installed perforated sheets with the following specifications on a 30 in. press with 340 sq. ft. of filter area:

14 gage (0.064 in. thick)
$\frac{1}{16}$ in. diameter perforations
$\frac{1}{8}$ in. regular staggered centers
75 holes/sq. in.
23% open area

Filtration conditions were identical to those in the first case except that working pressures were a little higher, ranging from 50 to 80 psig.

Results with this material have been remarkable. We have filtered at least 3,900,000 gal.

Test Cases Proved Perforated Sheets Feasible—Table I

Case	Products Filtered	Type Material Entrapped in Cake	Concentration of Filter Aid or Decolorizing Carbon
I	Alkylene oxide condensation products of phenol, bis-phenol-A, amines and lanolin.	Sodium salts and free polyol.	0.3–0.5% Super Cel ®.
II	Alkylene oxide condensation products of fatty acid esters, nonyl phenol, tall oil, fatty acids, fatty alcohols and Sorbo ®.	Sodium salts and free polyol.	0.3–0.5% Super Cel ®.
III	Esters from lauric, palmitic, stearic, oleic acids and Sorbo ®; esters from oleic and alkylene oxide condensation products of Sorbo ®.	Sodium phosphates, free polyol and decolorizing carbon.	0.8–1.3% Darco G–60 ® or Darco S–51 FF ®.
IV	Organic amine alkylaryl sulfonate. Calcium alkylaryl sulfonate (products are diluted with 30–50% benzene or Solvesso ® before being filtered.)	Foreign matter and $CaSO_4$.	1.0–1.2% Super Cel ®.

SEAMLESS

- Long radius or short—the finest [illegible]
  ...hot extruded for dimensional [illegible]
  and to [illegible]
- [illegible]
- [illegible]
- [illegible]
- [illegible]
- Produced [illegible]
  equipment designed with [illegible]
  technology [illegible]
  heat-treating [illegible]

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Savings in Money, Convenience Considerable—Table II

Case	Increased Filter Capacity	Filter Aid Reduction	Product Loss Reduction	Savings Over Cloth per Yr.
I	12.5%	16.7%	28.3%	$2,185
II	23.7%	13.3%	16.7%	3,960
III	0.0%	N. A.	5.0%	1,827
IV	25.4%	20.0%	20.0%	2,552
Average Savings	15.4%	12.5%	17.5%	$2,631

through one set of plates in three years. Though slight warping has occurred, we estimate the life span to be at least five years.

In another case, we fitted a 30-in. press having 213 sq. ft. of filter area with perforated sheets similar to those above. These have filtered approximately 2,200,000 gal. in three years at temperatures of 160 to 185 F. and pressures of 40 to 70 psig. with no signs of warping or any other wear. Five years looks like a reasonable life span for these sheets also.

A 350 sq. ft. press has filtered 800,000 gal. of various sulfonate slurries in 2½ years with no signs of wear.

Table I lists the type of material filtered. In all cases the objective was to obtain a clear filtrate using some type of filter aid or decolorizing carbon.

Table II shows the savings we obtained in each of the above cases.

▶ **These Benefits Followed**—The savings shown in Table II are not the only advantages gained through substitution of perforated metal sheets for filter cloths. Some others are:

1. We can clean a press faster than before, thus reducing downtime.

2. A backing material with constant, unchanging open area is far superior to one whose porosity constantly degrades to a point of uselessness. Constant porosity over many cycles gives the operator and engineer greater control of the filter process.

3. With elimination of variable porosity, we have greater control over experiments designed to increase press capacity and reduce product loss. We can also evaluate new filter aids and filter paper with greater accuracy.

4. Routine paper work and inventory control connected with cloth fabrics has been eliminated.

▶ **Some Considerations** — We have found that the following conditions must be met if a plate and frame filter press fitted with perforated metal sheets is to operate at optimum efficiency.

• Sealing surfaces of the filter plates should be as smooth as possible. If they are warped or have uneven surfaces due to mechanical damage or pit corrosion, they should be machined true and parallel. This will insure a tight metal to metal seal.

The filter frames do not require such careful attention since the gasketing effect of the paper would compensate for slight variations in surface finish.

We did not have any excessive leakage in any of our case studies.

• The perforated metal plate should be softer than, but certainly no harder than the metal in the press plates. This is especially true whenever a hydraulic closure unit is used for closing the press. If the perforated sheets are harder than the plates, dimpling may occur at the sealing surfaces.

• Filter paper should be of the proper weight. In our experiments, 15-lb. paper caused occasional breakage and filtrate contamination. We found that we could avoid breakage if we used a 20-lb. paper, so 20-lb. paper became standard.

• The metal selected for any perforated sheeting should be checked against the proposed application for corrosion resistance. You would not use an aluminum sheet in a press filtering caustic, for instance.

REFERENCES

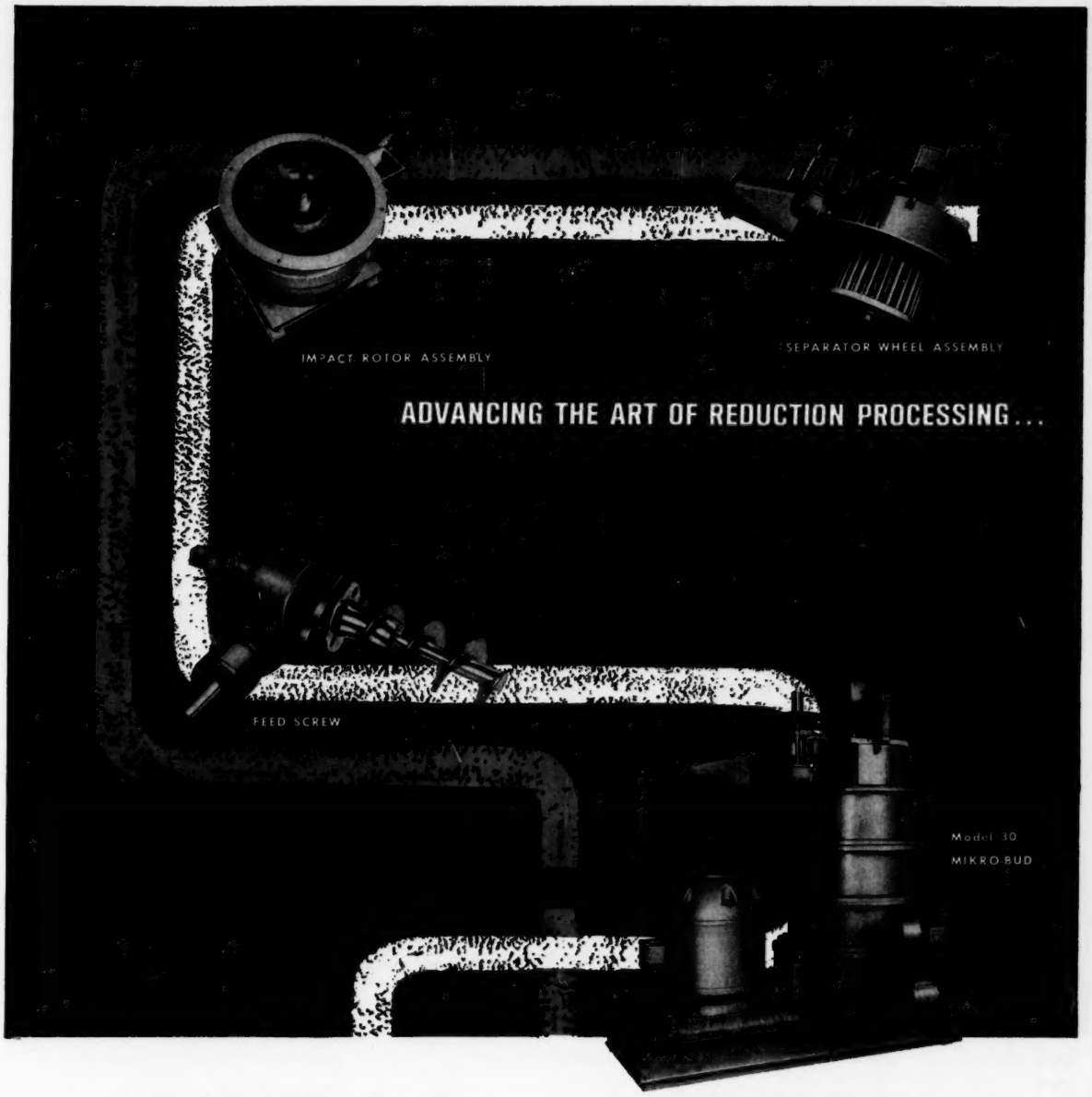
1. McCune, H. W., "Corrosion of Aluminum by Alkaline Sequestering Solutions," *Ind. Eng. Chem.*, **50**, 67 (1958).

C. WILLIAM BOYER is a Production Group Supervisor with Atlas Powder Co. at New Castle, Del. He is responsible for product yield and cycle control, equipment and process modifications and development of operating procedures. He has spent much time studying filtration processes and techniques on many products.

Mr. Boyer graduated from Franklin and Marshall college in 1955 with a B.S. in chemistry. He is a member of ACS.

CLARENCE E. AVERY, JR., graduated from the University of Rochester in 1943 with a bachelor's degree in chemical engineering. For the past 12 years, he has been a sales engineer in process equipment and filter media. Previously employed in the New York sales offices of Pfaudler Co. and Patterson Foundry and Machine Co., he now works for Eaton-Dikeman Co. at Mt. Holly Springs, Pa.

Mr. Avery is a member of ACS and AIChE.



Continual expansion of the processing industries demands equipment designed and developed for *today*. Our MIKRO-BUD is an example of this type of planning. Recent changes in this vertical hammer mill were dictated by field tests on a variety of materials including cocoa, rubber accelerators, sodium sulphate, sugar, phenolic resins, dyes, colors and tobacco. Capacities have been stepped up from 40 to 100 per cent, depending on the material in process. Efficient air flow has added to the range of heat-sensitive materials handled without coolants. A selector control wheel allows adjustment over a wide range of particle sizes without shutting down the mill. Write for Bulletin 51-C-1.

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CE COST FILE

No. 33: Labor Factors; Centrifugal Pump Systems

William R. Kane, Industrial Rayon Corp., Cleveland, Ohio

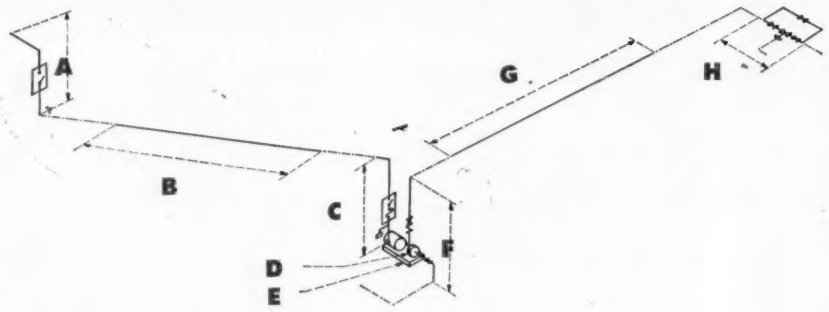
Compute Labor Needs to Install Pumps

Using Tables A-H below, modified by appropriate job condition factors, a quick estimate of labor man-hr. for installation of a pump system can be made, probably within 15% accuracy. If a more detailed estimate (counting up all fittings) is made using the man-hr./unit table, accuracy can be within 10%.

Basis for factors includes: installation in process battery limits of existing plant; general-purpose main power (440 v., 3 ϕ, 60 cps.); schedule 40 black pipe; 125 lb. cast iron fittings (1-2 in., screwed; 3-6 in., flanged). Assumptions, too, include power on separate branch line to one pump, 4 fittings/100 ft. in power header, a 6-in. high pump base with anchor bolts, and joints every 20 ft. in piping header.

After multiplying total job condition factor by total "normal" man-hr., add to normal man-hr. for total installation labor. Level of skill applies where skilled labor—of either plant or contractor forces—is inadequate.

If plant is equipped with modern electrical, pipe and machine shops, values are good for either contractor or plant. Job condition factor could be included for less-equipped plants. At valve station, man-hr. for any instrumentation is not included. Estimate does not include supervision, overhead, painting, holes through walls, etc.



A. Power at Disconnect Switch

	Man-hr.
30 amp	10
60	13
100	17
200	22

B. Power Header

(At 9 ft. elevation)

	Man-hr./lin. ft.
3 No. 14, ½ in. conduit	0.18
3 No. 12, ½ in. conduit	0.19
3 No. 10, ¾ in. conduit	0.23
3 No. 8, ¾ in. conduit	0.24
3 No. 6, 1 in. conduit	0.33
3 No. 4, 1¼ in. conduit	0.38

C. Power at Combination Starter

	Man-hr.
3 hp	11
7½ hp	13
25 hp	20
50 hp	28

D. Centrifugal Pump

	Man-hr.
2 in./1½ in., 3 hp	14
3 in./2 in., 7½ hp	16
4 in./3 in., 25 hp	22
6 in./4 in., 50 hp	32

E. Concrete Base

	Man-hr.
42 in. × 18 in.	11
48 in. × 20 in.	12
54 in. × 24 in.	13
72 in. × 30 in.	16

F. Piping at Pump

	Man-hr.
1½ in./1 in.	10
2 in./1½ in.	13
3 in./2 in.	17
4 in./3 in.	24
6 in./4 in.	35

G. Piping Header

(at 9 ft. elevation)

Dia.	Hanger Spacing	Man-hr./lin. ft. No fittings	Man-hr./lin. ft. 2 ells/100 ft.
1½ in.	8 ft.	0.25	0.26
2	8	0.30	0.31
3	12	0.40	0.43
4	17	0.49	0.53
6	20	0.69	0.75

H. Valve Station

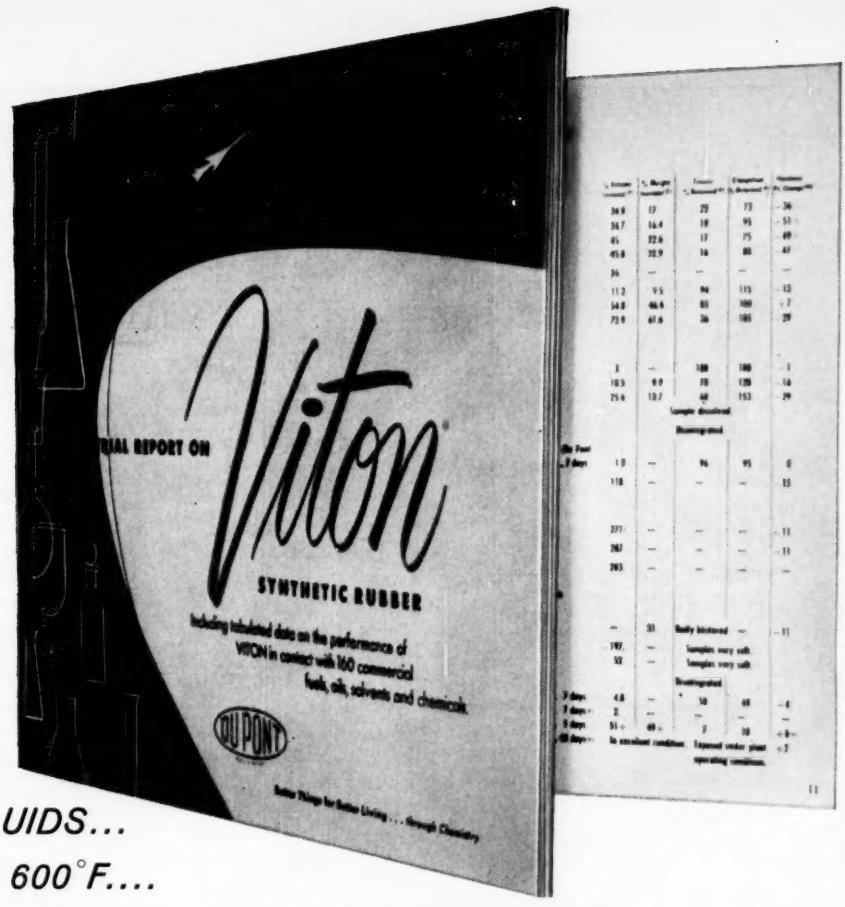
	Man-hr.
1½ in.	14
2	16
3	24
4	31
6	49

Job Condition Factors

Condition	Add
Size: ≥160 man-hr.	0%
80–159	5
32–79	10
Elevation: 10–25 ft.	1–16
Poor access	15–25
Constricted area	20–30
Fume area (masks)	40–60
Level of work skill	0–20
Contingencies	0–20
New plant: *deduct*	10–20

Basic Labor Factors for Pump System

Item	Unit	1 in.	1½ in.	2 in.	3 in.	4 in.	6 in.
elbow	each	0.65	0.85	1.0	0.9	1.2	2.0
tee	each	1.1	1.3	1.5	1.4	1.8	3.0
valve	each	1.1	1.3	1.5	1.4	1.8	3.0
flange	each				0.9	1.2	1.9
pipe	lin. ft.	0.15	0.20	0.25	0.31	0.37	0.5
tie-ins	each			To suit			



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- Enables auxiliary steam equipment to be readily adapted to the present equipment at only nominal cost.
- Reduces maintenance costs on producer equipment, tanks and distributing system for inert gas to a negligible figure.
- Practically eliminates the corrosion problem that would otherwise be associated with the inert gas system.
- Eliminates the problem of product contamination.
- Allows you to get rid of elaborate scrubbing systems.

Transparent Nomogram Is Handy for Operation

G. L. Head
Ammonia Dept., African Explosives & Chemical Industries, Ltd.
Northrand, Transvaal, So. Africa.

Sometimes useful information to aid process operators can be provided in the form of a nomographic chart. Examples are: required liquor rates for given gas rates on absorption towers; quantities of reactants required for reactions; and the like.

When this is the case it is useful to have the nomogram engraved on a plastic sheet which can be fixed on the operator's bench or secured to an instrument panel.

A length of nylon monofilament attached to a screw at the corner of the plastic sheet provides a handy means of reading the nomograph. The user holds the monofilament under tension in both hands and employs it as a "ruler" for taking readings.

Better Way to Read Emergency Delta P's

William L. Scheirman
Process Supervisor
Black, Sivalls & Bryson, Inc.
Oklahoma City, Okla.

Some time ago (*CE*, Aug. 11, 1958, p. 154) Kuong described a method of using two pressure gages to read pressure drop across an orifice, lacking a suitable manometer.

The difficulty with this idea is that it is rare to find two pressure gages calibrated exactly alike. Since the difference in readings is the value of interest it would be better to use a single gage and manifold it so it can take readings on both sides of the orifice. Good quality needle valves should be used since leakage between sides will cause erroneous results.

In use, several readings should be taken and averaged to eliminate momentary changes in flow while switching sides.

Y-Splitter Improves Gassing of Samples

Robert W. Moore
Attleboro Refining Co.
Attleboro, Mass.

Here's a handy idea for use in either the laboratory or the plant for control analyses.

Sometimes, when samples are being gassed for an analytical determination (e.g., with H_2S), it is handy to be able to gas a pair of samples simultaneously from the same gas cylinder. This is particularly true when the gassing cycle is long, say ½ hr. per sample.

At low gassing rates, such as six bubbles per second, and at very low pressures, it takes very careful equalization of liquid heights and depths of immersion of the gassing tubes if equal gassing is to be given each sample when using a common Y-divider from the gassing cylinder. The setup will often be initially equalized, only to have it become unbalanced when left unobserved.

There is a simple solution to the problem. Hang the Y-divider vertically and fill it with water or another suitable liquid. Connect the cylinder to the bottom inlet of the Y and the two Y-branches to the gassing tubes. The gas now divides equally between the legs of the Y by reason of its buoyancy and upward motion. The water acts as a check valve and forces the gas to continue on to the sample even with a variance in sample depth.

Next Issue: Watch for Winner of May Contest

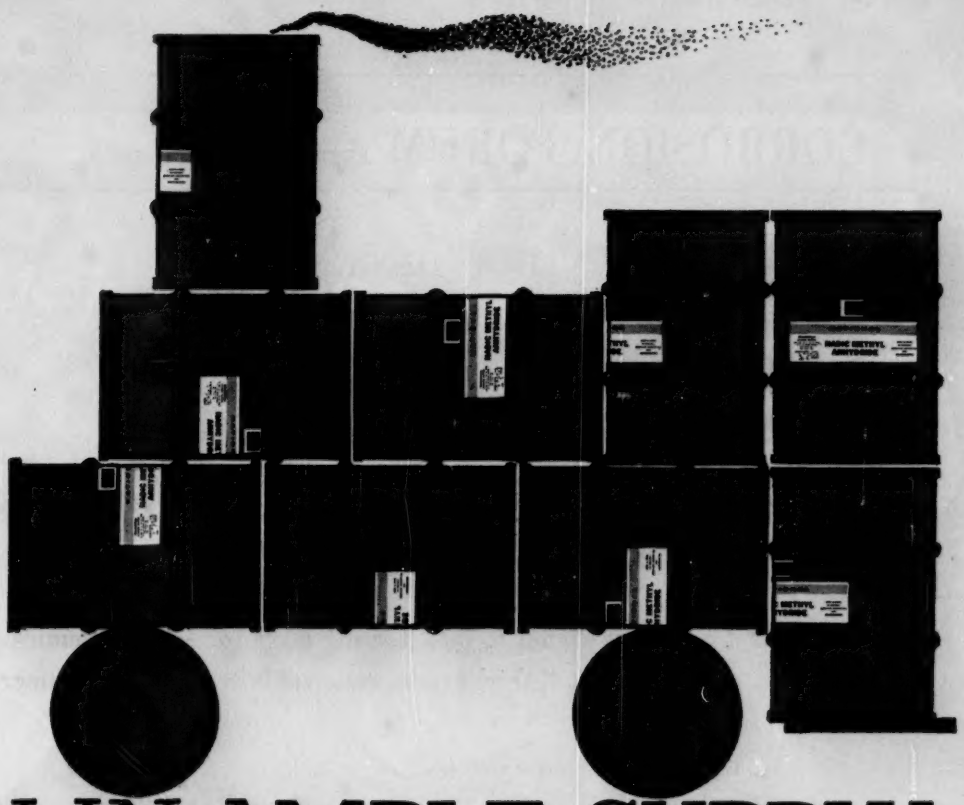
★ How Readers Can Win

$50 Prize for a Good Idea—Until further notice the Editors of *Chemical Engineering* will award $50 each four weeks to the author of the best short article received during that period and accepted for Plant or Process Design Notebooks. Each period's winner will be announced in the second following issue and published in the third or fourth following issue.

$100 Annual Prize—At the end of each year the period winners will be rejudged and the year's best awarded an additional $100 prize.

How to Enter Contest—Any reader (except a McGraw-Hill employee) may submit as many contest entries as he wishes. Acceptable material must be previously unpublished and should be short, preferably not over 500 words, but illustrated if possible. Acceptable nonwinning articles will be published at space rates ($10 minimum).

Articles should interest chemical engineers in development, design or production. They may deal with useful methods, data, calculations. Address Plant & Process Design Notebooks, *Chemical Engineering*, 330 W. 42 St., New York 36, N. Y.



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PRACTICE . . .

CORROSION FORUM

EDITED BY R. B. NORDEN

CORROSION-CONTROL DESIGN

Part of a series appearing throughout 1960

4a First of two articles on valve design

Valve Design: Special for Corrosives

Here's what to look for in valves for severe chemical service: no extra wall thicknesses, removable seat rings or immersed threads.

E. G. Holmberg, The International Nickel Co., New York, N. Y.

The chemical process industries, and chemical engineers in particular, place a heavy burden on valve manufacturers, with demands for valves capable of standing up to severely corrosive chemicals.

Most engineers are aware of the many new materials of construction developed as a partial answer to this situation. But many people may not be aware of the fact that there are, now, some proved valve-design principles aimed at corrosive service and that design is a vital factor in extending valve life. In this first of two articles, we will discuss these principles.

It is not our purpose to encourage chemical engineers or mechanical engineers to develop new corrosion-resistant valve designs, but rather to familiarize them with the design details which engineers for valve manufacturers have learned are essential for corrosive applications.

Because the new alloys were considerably more expensive than carbon steel or low-alloy steels, valve manufacturers recognized at the outset that new designs were necessary to lower costs. This, at first led to adoption of a lightweight design for 150 lb. pressure class valves similar to the SP-2 standard for brass valves. Many features of this early construction were incorporated in SP-42 for corrosion-resistant valves. (SP standards are established by the Manufacturers Standardization Society of the Valve and Fitting Industry).

▶**Competent Design**—Valve designers, to produce a successful design, must consider a number of items: (1) characteristics of specific alloys when subjected to various fabricating and exposure conditions, (2) effect of design in overcoming detrimental corrosive effects and (3) practicability of the design for producing sound castings.

Alloys suitable for handling a particular corrosive should be determined by a competent corrosion engineer.[1, 2, 3, 4]

Knowing which alloys can be used for a specific application, it is the responsibility of engineers designing valves to be informed about (1) castability, (2) limits of machinability, (3) weldability, (4) effect of welding on alloy structure, (5) relative erosion resistance, (6) susceptibility to crevice corrosion and (7) galvanic behavior.

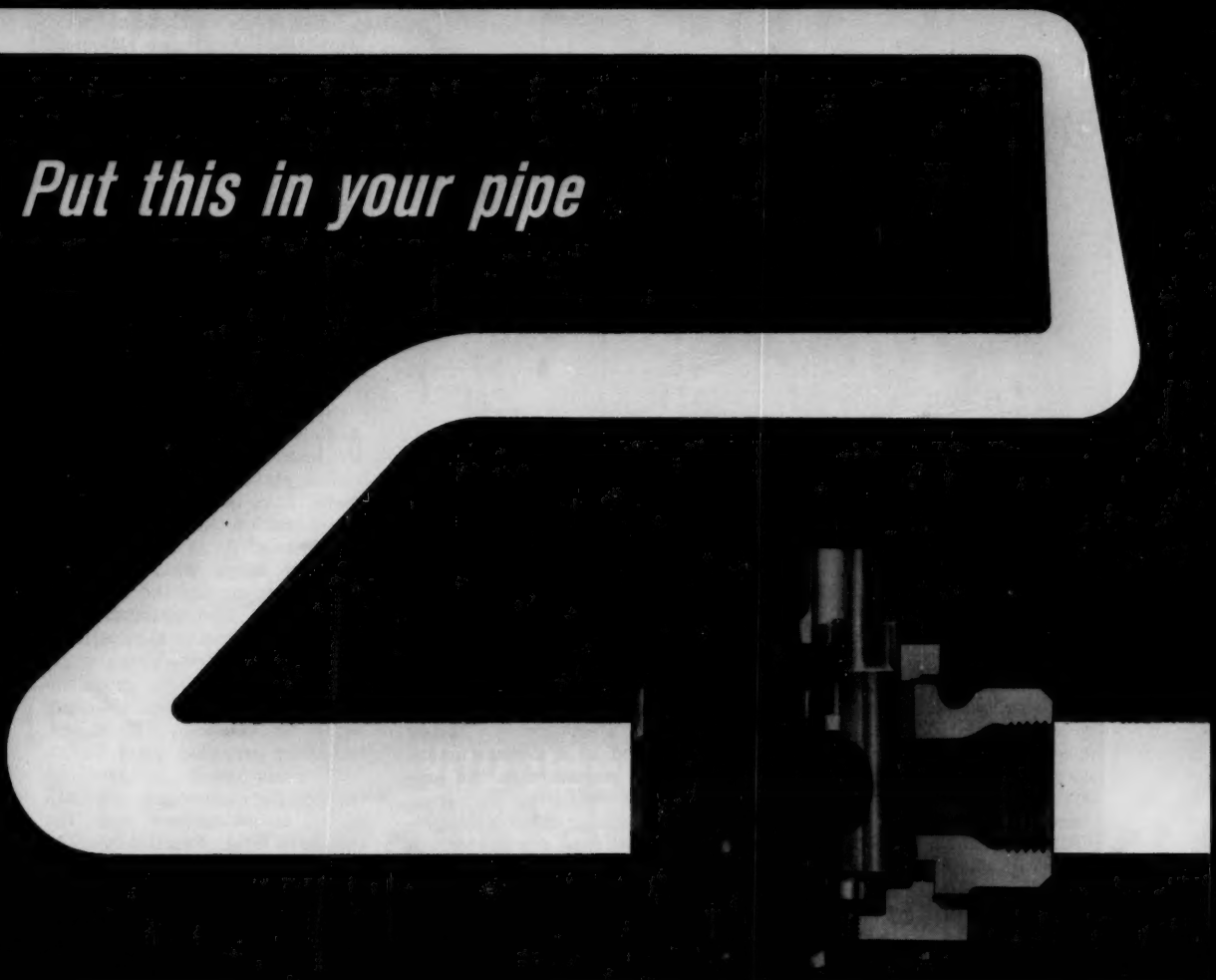
Contrary to common belief, a wide variation does not exist in the casting behavior of most alloys used for corrosive applications. Valve patterns designed for the casting of one alloy can usually be used without modification for other alloys. A successful valve casting design (and pattern design) will be dependent upon close collaboration between the designers and foundry personnel. Many poor casting

1. Plant Site, Layout Minimize Corrosion, Jan. 11, 1960, p. 144.
2. Proper Design Voids Equipment Corrosion, Feb. 22, 1960, p. 162.
3a. Often Overlooked Reactor Design Factors, May 2, 1960, 150.
3b. Keys to Corrosion-Wise Reactor Design, May 16, 1960, p. 170.

Future Articles

Design of heat exchangers to minimize corrosion.
Storage tank design.
Design of mixers to minimize corrosion.

Put this in your pipe



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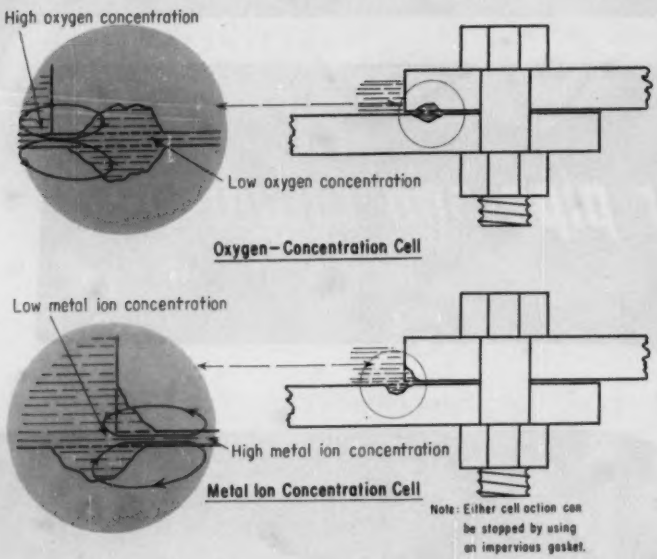

High oxygen concentration
Low oxygen concentration
Oxygen–Concentration Cell
Low metal ion concentration
High metal ion concentration
Metal Ion Concentration Cell
Note: Either cell action can be stopped by using an impervious gasket.

CREVICE CORROSION in valves: proper gasket will stop this attack.

designs are the result of inadequate or complete lack of consideration of the flow and solidification characteristics of metals in molds.

▶ **Can Be Machined**—With the exception of the high-silicon irons, practically all corrosion-resistant alloys are amenable in some degree to machining operations. Threading of one or two grades, such as Hastelloy alloy D, calls for special techniques. All of the corrosion-resistant alloys require similar cutting tools and machining techniques. The cutting tools, surface cutting speed and rate of feed employed in the machining of bronze, cast iron, carbon steel and low-alloy steels are not applicable for the more highly alloyed materials. These alloys need top quality high-speed tungsten-carbide or Carboloy cutting tools, a relatively slow machining speed, and for most grades, because of susceptibility to work-hardening, a heavy feed rate during initial machining operations.

Machining costs for valves produced in corrosion-resistant alloys will be higher than for conventional materials because of the need for more expensive cutting tools, a somewhat inferior tool life and a lower production rate which is a byproduct of machining limitations.

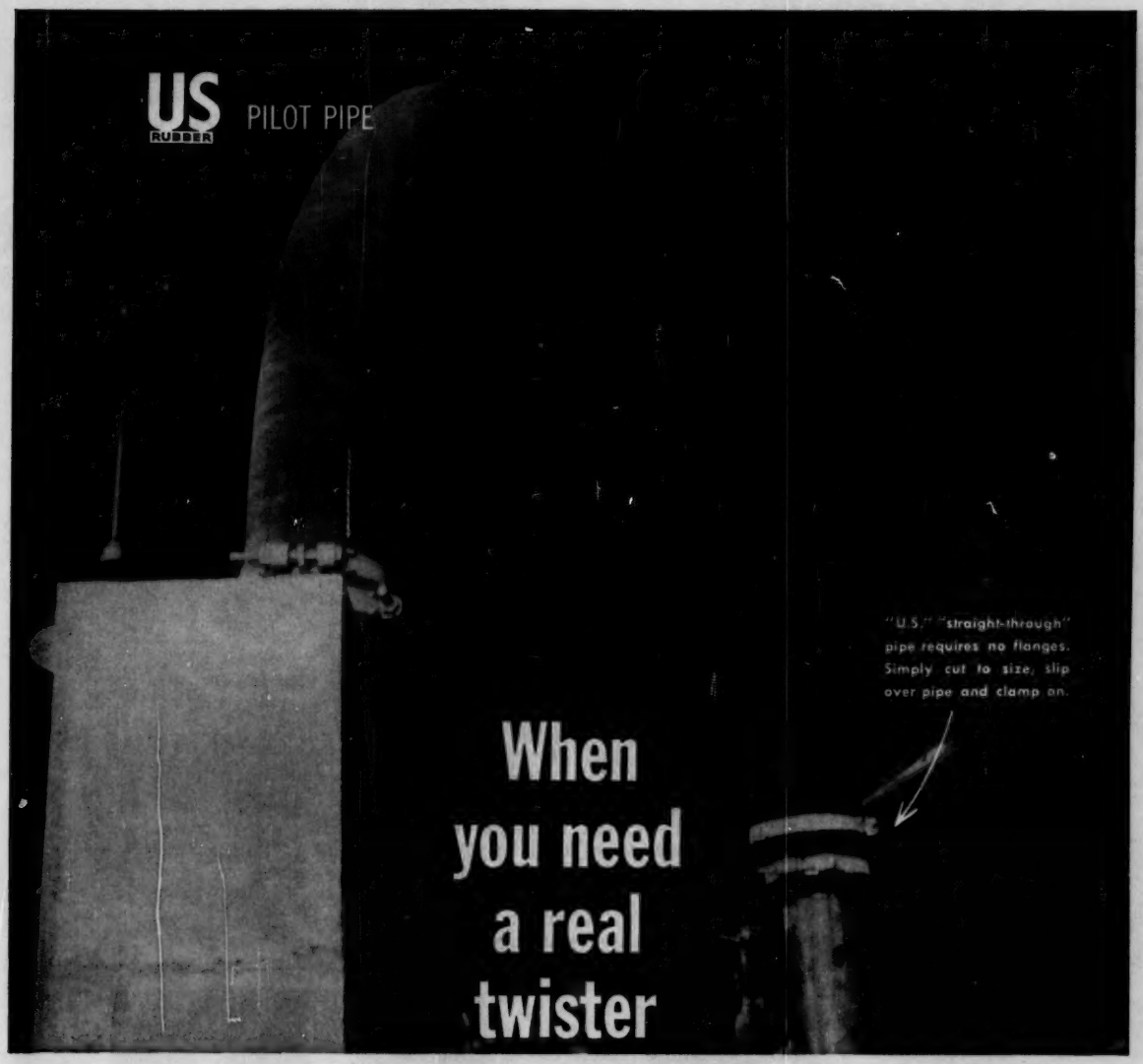
▶ **Welding Problems** — Welding is employed as a normal manufacturing procedure in the production of "fabricated" valves. Rarely is it used as a normal procedure in the production of valves which have cast bodies and bonnets. Welding might be applied in cast designs where: (1) a repair is justified to salvage a casting, (2) welding is the only practical means for attaching a specific component (3) a hard corrosion-resistant alloy has to be applied on metal-to-metal seating surfaces, when only a valve of this design is considered suitable for handling a liquid containing abrasive solids. Actually, improved manufacturing techniques developed by makers of corrosion-resistant valves have eliminated, as a regular procedure, the need for hard-facing seating surfaces or the use of dissimilar materials to avoid galling.

Whenever there is a welding operation in the construction of valves employing corrosion-resistant alloys there is a strong possibility of producing a structure change which will have a deleterious effect on corrosion resistance. For example, it is well known that welding of austenitic stainless steels which do not contain carbide-stabilizing elements or that are not of the extra-low-carbon variety, will result in sensitization of the structure adjacent to welds; if not subsequently annealed, these areas will be susceptible to intergranular corrosion when exposed to certain corrosive liquids.

▶ **Hardness Fallacy**—The high order of resistance to erosion demonstrated by virtually all alloys employed for corrosive applications indicate that it is a fallacy to believe that hardness is an important criterion in overcoming this effect. Virtually all of these alloys have relatively low hardness values. But austenitic stainless steels, for example, have better resistance to steam erosion than nitrided low-alloy steels.[8] It is this property of these alloys which make it practical to employ the integral-seat design in construction of valves for corrosive applications.

▶ **Watch Crevices**—Valve engineers are particularly conscious of the damaging effect that can occur in crevices. Therefore, whenever practical, good design will avoid such features as threads for components that will be in direct contact with the corrosive fluid. Practically all of the corrosion-resistant alloys are susceptible to either one or the other of the two principal forms of crevice corrosion illustrated in the sketch. Chromium-containing alloys, which depend upon oxygen to maintain passivity, will be most susceptible to the oxygen concentration form of crevice attack. In this case oxygen is consumed in the crevice, resulting in a loss of passivity and causing this area to become anodic to areas in contact with the main body of the solution where the oxygen concentration is higher.

Alloys that do not contain chromium and, therefore, are not entirely dependent upon the formation of a passive oxide film for their corrosion resistance, will tend to favor the metal-ion concentration form when attack occurs in crevices. This attack results when the concentration of metal ions in the crevice becomes greater than in the main fluid body. This crevice area will be-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come cathodic to adjacent areas, resulting in accelerated attack at the outside edge of the crevice. Each of these cells will cause current to flow as shown in the enlarged views of the sketch on p. 240.

▶**Galvanic Effects**—Valves required for handling corrosive fluids will rarely use dissimilar alloys for components that will be in contact with the fluid. The economics of material selection and design will usually dictate use of a single alloy for all of these features. Therefore, galvanic-corrosion effects are usually not of great concern to engineers who design corrosion-resistant valves. It is important, however, that they be aware of this behavior should special conditions call for dissimilar-alloy combinations.

A study of a galvanic metals series will reveal that practically all of the more highly corrosion-resistant alloys are located within one or two groups of each other.* This indicates that no serious galvanic effect would result should they be used in contact with each other in a corrosive fluid.

Although ill effects may result when an improper combination of alloys are used in valve construction, under some conditions advantage may be taken of galvanic behavior to improve valve performance. An example of this would be the use of Monel nickel-copper alloy trim in a bronze valve required for sea water service. Under these conditions the Monel trim will be protected without serious galvanic action on the bronze.

Experience shows that graphite, which is cathodic to virtually all commercially available alloys, should be avoided in asbestos packing and gaskets. Asbestos packing lubricated with graphite will galvanically accelerate attack of valve stems when the packing area becomes wetted with the corrosive being handled and when it remains in one position for extended periods. Asbestos packing lubricated with petrolatum, mica dust and other lubricants that are inert will not produce this effect.

With the advent of Teflon, a new inert material became available which is ideally suited for packing, gaskets, and valve-seating surfaces. It has no known solvent, and with the exception of molten alkali metals, fluorine and chlorine trifluoride at elevated temperatures, is resistant to all chemicals encountered in the chemical industry in the temperature range −320 F. to 550 F.

▶**Early Mistakes** — Valves for corrosive applications do not include in their design either extra wall thickness as a corrosion allowance or removable seat rings. Early proponents contended that these features would permit confining the use of the more expensive corrosion-resistant materials to critical parts such as seat rings, disk and stem, while less expensive, less corrosion-resistant materials could be used in the body and bonnet. The design failed, of course, because of accelerated attack of the body material around seat rings. This eventually led to excessive leakage and in many cases complete loosening of the seat rings so that they fell out of position.

The corrosive forces acting to bring about these failures were (1) a relatively high rate of uniform attack on the body material, (2) galvanic behavior between the seat ring and body material and (3) crevice corrosion which developed in the threaded or pressed joint employed to secure the seat rings in place. Valves of this construction in which low-cost materials such as carbon steel are used for bodies and bonnets and more corrosion-resistant alloys for trim, are still regular production items for relatively noncorrosive applications by most manufacturers.

▶**Costs Are Down** — Considerable progress has been made by manufacturers of corrosion-resistant valves in adopting more efficient production procedures. This is reflected in a comparison of quotations for 150 lb. pressure class 2-in. and 3-in. flanged-end gate and globe steel valves with stainless Type 304 or 316 valves of these types in the corrosion-resistant design. In some cases the all-stainless valve will be less expensive than the steel construction with alloy trim, while in others they will be competitive. For valves of these types and in these sizes, economics favor purchasing the all-stainless valve for corrosive and noncorrosive applications.

▶**Second Article Coming**—The second article on valve design will appear in the next issue and will take up specific pros and cons about globe, gate, Y, diaphragm, plug, needle and sampling valves for corrosive process service.

* This includes (going from most anodic to most cathodic) magnesium and magnesium alloys; zinc; aluminum 2S; cadmium; aluminum 17ST; steel or iron, cast iron; chromium-iron (active); Ni-Resist; 18-8 chromium-nickel iron (active), 18-8-3 chromium-nickel-molybdenum iron (active); lead-tin solders, lead, tin; nickel (active), Inconel (active), Hastelloy C (active); brasses, copper, bronzes, copper-nickel alloys, Monel; silver solder; nickel (passive), Inconel (passive); chromium-iron (passive), titanium, 18-8 chromium-nickel iron (passive), 18-8-3 chromium-nickel-molybdenum iron (passive), Hastelloy C (passive); silver; graphite, gold, platinum.

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EMIL G. HOLMBERG has been in the corrosion field for 25 yr. He is a member of the application engineering section of Inco's development and research division in charge of materials application in the process industries. Prior to his association with International Nickel, Mr. Holmberg was employed for 11 yr. with E. I. du Pont and for 9 yr. with Alloy Steel Products Co., Linden, N. J. He has been active in various technical society matters pertaining to corrosion and is the author of a number of papers on various aspects of this subject.

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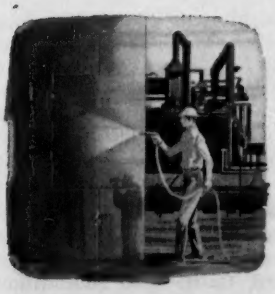

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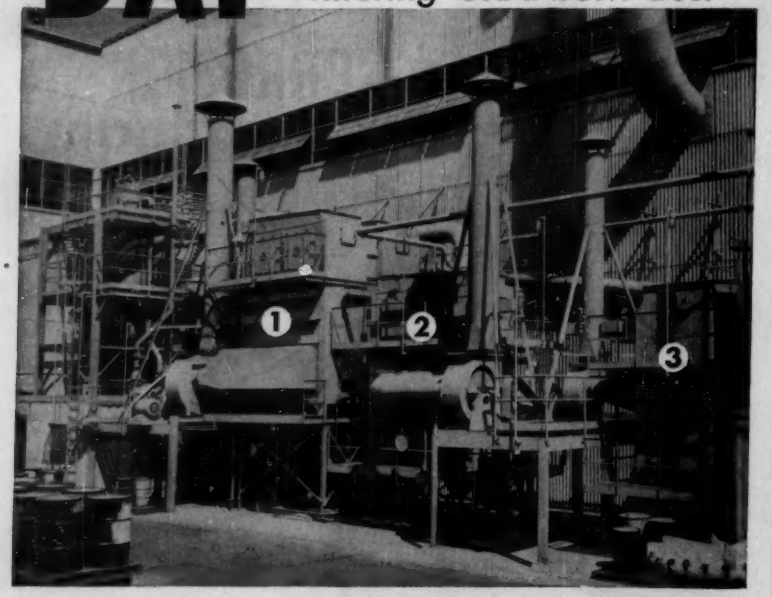

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(*Continued from page* 88)

refinery in August. Unit will have a design capacity of 10,500 bbl./day feed, making it the largest propane deasphalter in the U. S. Heart of the unit will be three towers, each 9 ft. dia. by 70 ft. high, which will be equipped with rotating disk contactors. Foster Wheeler Corp. will design and erect the deasphalter itself; Sun will handle the auxiliary facilities. Propane-extracted stream will be used as catalytic cracker feed, and the residue will be either used as fuel or converted to asphalt.

Pan American Sulfur Co. has recently opened a 50,000-ton bulk sulfur storage and loading facility at Tampa, Fla. The new installation, shown above, receives sulfur from the firm's mines in Mexico. Delivered in a specially-designed ship, the sulfur can be transferred directly from the ship's hold into railway cars on an adjacent 40-car siding, or onto hard-surfaced bulk sulfur storage areas. The installation also has a heating and filtering unit, and liquid sulfur can be delivered to industrial users in a 250-mile radius. Sulfur-handling equipment was designed by Brown & Root, constructed by Mid-Valley, Inc.

Armstrong Rubber Co. announces that it will erect a tire producing plant at Hanford, Calif. The $25-million facility will be built by late 1961, will produce 10,000 tires daily.

Solar Nitrogen Chemicals, Inc., jointly owned by Standard Oil Co. (Ohio) and Atlas

Powder Co., will build a $15-million plant near Joplin, Mo., to make anhydrous ammonia, urea and related products. Atlas will operate the plant, and Sohio Chemical Co. will market its output.

Union Carbide Chemicals Co. is now operating its new Technical Service Laboratory pictured above. Located at Tarrytown, N. Y., it centralizes and expands Carbide's customer service and use-research which had formerly been carried out at several locations. The laboratory building accommodates about 100 scientists and a supporting and administrative staff of 50. Main building, 300x60 ft., houses offices, public areas and 46 laboratories. A mechanical test building is connected to the main building.

Pana Refining Co. has started up the 500-bbl./stream-day UOP Merox unit pictured above. Located at Pana, Ill., the installation sweetens and extracts mercaptans from thermal gasoline. It was assembled by converting a former caustic scrubbing unit and a former copper treating unit.

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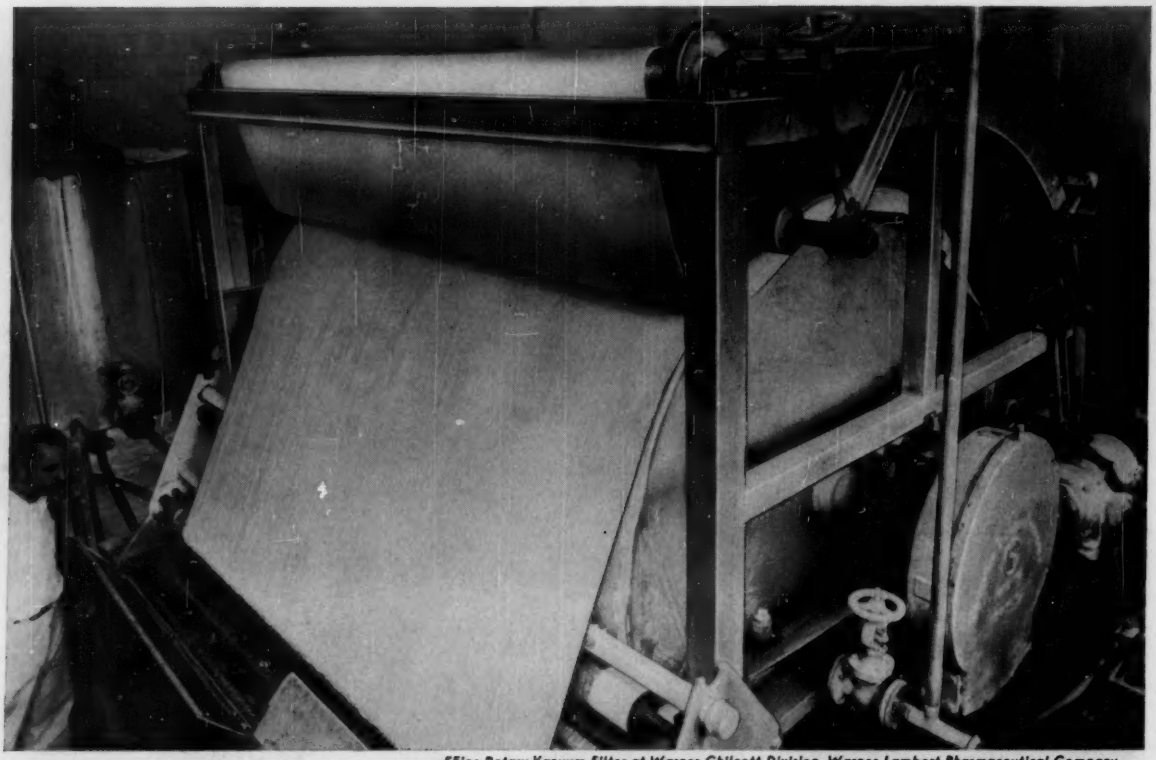

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lantic Refining, Tidewater Oil and Continental Oil, has started up a natural gasoline and bottled-gas-products unit at Grand Cheniere, La., reported to be the largest of its kind. The plant, built under a project known as "Operation Pig Squeal," processes about 175 million cu. ft./day of offshore natural gas. It extracts gasoline, propane and butane, using an activated carbon and silica gel adsorption system which consists of eight 20-ft.-high towers. The system scarcely shrinks the stream of natural gas which passes through it and on to consumers.

Valley Nitrogen Producers, Inc., have recently taken over operation of the above-shown ammonium phosphate and wet-process phosphoric acid plant. The Helm, Calif., facility was engineered, built and started up for Valley Nitrogen by the J. C. Carlile Corp. of Denver. It has a capacity of 75,000 tons/yr. ammonium phosphate and complex fertilizers, and 16,500 tons/yr. wet-process phosphoric acid.

Nopco Chemical Co. announces that it has completed construction plans for an isocyanates plant in New Jersey. Expected to be producing by January, 1962, the installation will have a design capacity of 10 million lbs./yr., expandable to twice this figure. Main product will be toluene diisocyanate, which Nopco uses in making urethane foams. Plant is expected to cost about $7 million.

Southern California Edison Co. may start building a 360,000-

Handling
Hot Fumes?
Bifurcate 'em!

A protective housing shields a DeBOTHEZAT Bifurcator motor from contact with hot and corrosive fumes. Special alloys for housings and fan blades are available for extremely corrosive fumes. The result: smoother operation and lowered motor maintenance costs. Space-saving duct installation ends sharp-corner deflection to reduce friction and increase velocity.

For details on how DeBOTHEZAT Bifurcator Fans can improve ventilating efficiency, contact a DeBOTHEZAT engineer now or write direct. Address Dept. CED-660.

De Bothezat® FANS
A DIVISION OF
American Machine and Metals, Inc.
EAST MOLINE, ILLINOIS

IN CANADA: Represented by DOUGLAS ENGINEERING LTD., Toronto • Montreal

Divisions of American Machine and Metals, Inc.
TROY LAUNDRY MACHINERY • RIEHLE TESTING MACHINES • DE BOTHEZAT FANS • TOLHURST CENTRIFUGALS • FILTRATION ENGINEERS • FILTRATION FABRICS • NIAGARA FILTERS • UNITED STATES GAUGE • RAHM INSTRUMENTS • LAMB ELECTRIC COMPANY • HUNTER SPRING COMPANY GLASER-STEERS CORPORATION

NIAGARA VERTICAL FILTER AT KIND AND KNOX GELATIN COMPANY, CAMDEN, N. J.

"In half the time needed by our old filter press, we can run a batch of gelatin in the thin liquor stage through our new NIAGARA VERTICAL FILTER," says Edward Bohn Jr., assistant plant superintendent for one of the largest U. S. gelatin producers.

Remarkable reductions in down time and labor costs also are reported by Kind and Knox with its new NIAGARA FILTER. "Resetting the NIAGARA for a new run takes one-fourth the time and one man can handle the procedure without a helper," Bohn says. "Our regular filter press requires two men working two hours to change 50 filter cloths. With NIAGARA, hot water under pressure completely removes the residue in minutes, and the unit does not have to be opened. Also, there are no filter cloths to clean or replace in our NIAGARA FILTER."

The plant operates 24 hours a day, 7 days a week, and to date there has been no operational trouble with the NIAGARA FILTER. This compact filter has a base measurement of only 52" x 102", so there is a big savings in floor space.

For details on how custom engineered NIAGARA FILTERS can help with your processing problems, write for bulletin NC-457, or see the NIAGARA section in Chemical Engineering Catalog.

Niagara® FILTERS

A DIVISION OF

American Machine and Metals, Inc.

DEPT CEN—660

EAST MOLINE, ILLINOIS

Divisions of American Machine and Metals, Inc.,

TROY LAUNDRY MACHINERY • RIEHLE TESTING MACHINES • DE BOTHEZAT FANS • TOLHURST CENTRIFUGALS • FILTRATION ENGINEERS • FILTRATION FABRICS • NIAGARA FILTERS • UNITED STATES GAUGE • RAHM INSTRUMENTS • LAMB ELECTRIC COMPANY • HUNTER SPRING COMPANY GLASER-STEERS CORPORATION

kw. atomic electrical power plant next year, which would be the largest in the U.S. Company has sent out letters of intent to negotiate design and construction contracts: one to Westinghouse, for the reactor; another to Bechtel, for construction. Plant would cost about $70 million and would require about four years construction time. It would use a closed-cycle water reactor having uranium oxide fuel elements. Westinghouse and Edison studies show that the installation would be competitive with conventional plants over its lifetime.

General Aniline & Film Corp., Dyestuff and Chemical Division, has appointed Superior Materials, Inc., of New York City to be distributor of GAF pigments, dyes and paint chemicals in the metropolitan New York area.

Aerotest Laboratories, Inc., of Deer Park, N. Y., announces affiliation with Technik, Inc., of Garden City, N. Y. Move provides advanced research, development facilities for independent testing firm Aerotest.

Dayton Dayflex Plastics Co. is a newly-announced division of the Dayco Corp., Dayton, Ohio. Division will control manufacture and sales of various plastics goods, as well as doing product development and test work.

Ebasco Services Inc. has announced the affiliation of Charles Roberts Associates Inc., a marketing and distribution consulting firm. Move reflects expansion of Ebasco's activities in management consulting.

Portland Cement Association is establishing a new regional

office at Austin, Tex. It will serve the Association's newly-formed South Central Region, consisting of Oklahoma, Arkansas, Louisiana and Texas. A new district office to serve New Mexico has also been set up, at Albuquerque.

United Carbon Co. has introduced the new trademark shown above. Among the reasons for choosing it are its suggestion of three dimensions and its expected flexibility in use.

Strong, Carlisle & Hammond, a division of White Sewing Machine Corp., reveals that American Steel Export Co., Inc., will handle international sales of Strong's steam traps, strainers, reducing valves and separators.

OVERSEAS BRIEFS

El Salvador: Central America's first chemical fertilizer plant, to cost $10 million, will be built near the Pacific port of Acajutla. A new firm, Fertilizantes de Centro America, S.A., will operate the plant. It will supply Guatemala, El Salvador, Costa Rica, Nicaragua, Honduras and Panama.

Japan: Osaka Gas Co. will greatly expand its production

BATCH-O-MATIC® provides high efficiency and constant quality control at MERCK & CO., INC.

This completely automated Tolhurst BATCH-O-MATIC meets this user's requirements for a dual-purpose extractor.

In the first application, excellent recovery of filtrate is obtained and *solids are discarded.*

In the second application, extremely high purity standards are maintained for solids which are saved. Here, *filtrate is discarded.*

BATCH-O-MATIC operation reduces exposure time and, therefore, maintains product stability.

Automatic operation, no crystal degradation during unloading, stepless variable basket speed, trouble-free performance and low operating costs helped determine the selection of a BATCH-O-MATIC. For more complete data, see the Tolhurst section in Chemical Engineering Catalog or write: Address Dept. CET-660, East Moline, Illinois.

Tolhurst® CENTRIFUGALS

A DIVISION OF

American Machine and Metals, Inc.

Specialists in liquid-solids separation

EAST MOLINE, ILLINOIS

Divisions of American Machine and Metals, Inc.,

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Sealing Corrosives?

Teflon* Gaskets and "O" Rings Definitely Reduce Costs

... last for the life of the connection even in services such as concentrated acids, alkalis or solvents (except molten alkali metals).

... permit easy joint breaking without tearing or pulling—eliminate replacement cost and lost maintenance time for refinishing flange surfaces.

... can be used again and again—assure decided savings where joints must be frequently broken for cleaning and inspection.

Reduce *your* corrosive sealing costs with John Crane Teflon Gaskets, "O" Rings and Back-Up Rings. They are available in a full range of types and sizes, envelope or solid, also specials to specification. Request Catalog P-327 for complete facts.

Crane Packing Co., 6451 Oakton St., Morton Grove, Ill. (Chicago Suburb).
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

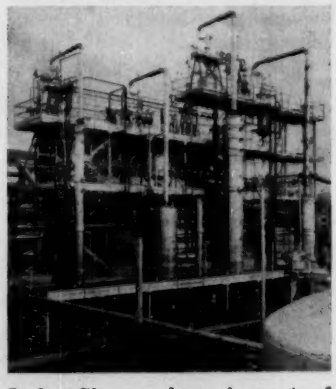
*DuPont Trademark

John Crane — MECHANICAL PACKINGS — SHAFT SEALS — TEFLON PRODUCTS — LAPPING MACHINES — THREAD COMPOUNDS

CRANE PACKING COMPANY

facilities by installing a British-type petroleum manufactured gas plant, which will be the largest of its kind in Japan. Plant will cost about $2.2 million, and is scheduled for completion late this year. Construction contract was made with Humphreys & Glasgow, Ltd., of London; actual construction will be done by a Japanese licensee of Humphreys & Glasgow.

Germany: The General Atomics Division of General Dynamics Corp. (Calif.) has entered into a licensing agreement on nuclear reactor systems with Gutehoffnungshutte Sterkrade A.G. of Germany. Latter firm will have exclusive rights to make and sell General Atomics' major advanced reactor systems, for research or commercial power generation, in the Federal Republic of Germany.



Italy: Shown above is part of Montecatini's new 12-million-lb./yr. commercial plant for producing Meraklon, an isotactic polypropylene staple fiber said to have several outstanding properties. Company expects that demand for product will justify a capacity increase to 60 million lb./yr. by 1962. Plant raw material is propylene monomer.

Egypt: Government agencies have okayed a project to build a fluid coking plant at Suez. Plant will run about 1.6 million tons/yr. heavy Belayim crude (containing 91% residual fuel) stock to produce

HIGHER *Thermal Efficiencies . . . . .* ***GREATER*** *Savings In Industrial Process Heating!*

THE HI-TURBIANT HEATER

If you have any process operations — large or small — where process fluids are heated, directly or indirectly, investigate now the substantially greater thermal efficiencies and lower operating costs the Hi-Turbiant Heater is bringing to other processing applications similar to yours.

▶ As shown in the cutaway view, the Hi-Turbiant has both radiant and re-radiant heating zones — a unique advancement that insures more uniform heat absorption throughout the entire tubular network!

▶ High fluid turbulence, maintained by high-temperature pumps, reduces boundary-layer vaporization and assures substantially greater heat efficiencies without vaporization problems!

▶ More uniform heating permits greater height-to-diameter ratio — therefore fewer "hairpins" in the tube system for more efficient fluid flow, lower pumping costs, greater operating economies!

Because of these and other unique Hi-Turbiant advancements, you make multiple savings in process heating applications — savings in size of unit required, savings in fuel costs, savings in pumping costs, savings in plant space. Send for illustrated bulletin that gives detailed data and shows typical systems. *Ask for Bulletin #HT-100!*

TWO BROAD FIELDS OF APPLICATION!

1. Heating Transfer Fluids (Dowtherm, Aroclor, Hydrocarbon oils, etc.) used in heat processing.
2. Direct Firing of process streams (Rich-Oil denuding, asphalt heating, etc.) where fluids must be heated under close thermal control.

In both types of application, the Hi-Turbiant Heater brings new standards of efficiency, new savings in processing costs!

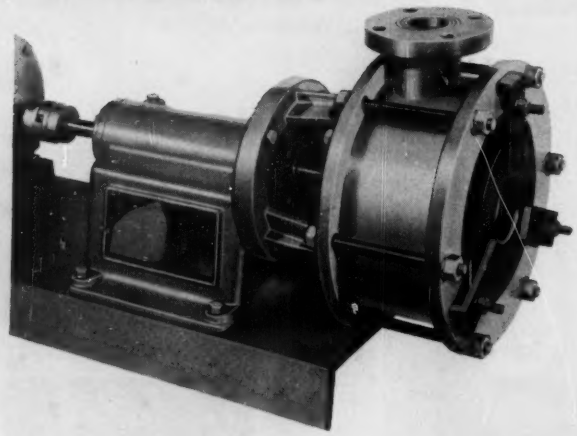
COMPLETE RANGE OF SIZES — ½ TO 40 MILLION BTU/Hr.

Also, single user "package" units 200,000 to 1,500,000 BTU/Hr.

There's a Hi-Turbiant Heater to fit your requirements!

WESTERN PRECIPITATION
DIVISION OF JOY MANUFACTURING COMPANY
1000 WEST 9TH STREET, LOS ANGELES 54, CALIFORNIA
NEW YORK 17 • CHICAGO 2 • PITTSBURGH 2 • ATLANTA 5 • SAN FRANCISCO 4
IN CANADA: 6582 MOUNTAIN SIGHTS AVENUE, MONTREAL, P. Q.

VANTON CENTRIFUGAL PUMPS in PVC and POLYPROPYLENE



TO HANDLE HCl, H_2SO_4, MOST ACIDS, PLATING SOLUTIONS AND MANY SOLVENTS

Because the wetted parts of these pumps are constructed of unplasticized, unmodified polyvinyl chloride or Polypropylene these pumps offer the broadest possible range of corrosive resistance as well as the non-contaminating transfer of sensitive solutions.

Vanton Centrifugal pumps which are available in a broad range of sizes have capacities of 10 through 180 GPM; discharge heads to 160 feet and are lower in cost than many special alloy pumps for similar applications.

These pumps are ruggedly constructed, are engineered for efficiency and have mechanical shaft seals of the latest design in a range of materials to cover all corrosive applications and deliver top, low-maintenance performance in all applications. *WRITE FOR SPECIFICATIONS INFORMATION.*

Vanton PUMP & EQUIPMENT CORP.

DIVISION OF COOPER ALLOY CORP., HILLSIDE, N. J.

INDUSTRY NEWS . . .

much-needed middle distillates for area. American West German, French and Italian firms have made offers to build the plant.

North Africa: Plant expansion continues at Compagnie Francaise des Petroles' crude oil stabilization facilities at Hassi Messaoud in the Sahara oil fields. The finished plant is to put out 100,000 bbl. crude/day. One design feature is the effective removal of very large amounts of wild gas from well fluids.

Burma: A $2 million plant to make superphosphates and sulfuric acid will be built near Rangoon. Almost certain to get the construction contract is Fertilizers & Chemicals, Ltd., of Israel. Plant will take about two years to complete.

NEW LOCATIONS

Union Carbide Corp. has begun transferring employees to its new home office, the 52-story Union Carbide Building on Park Ave. in New York City. Building will house about 5,000 people. Carbide plans to complete the personnel transfer by this fall.

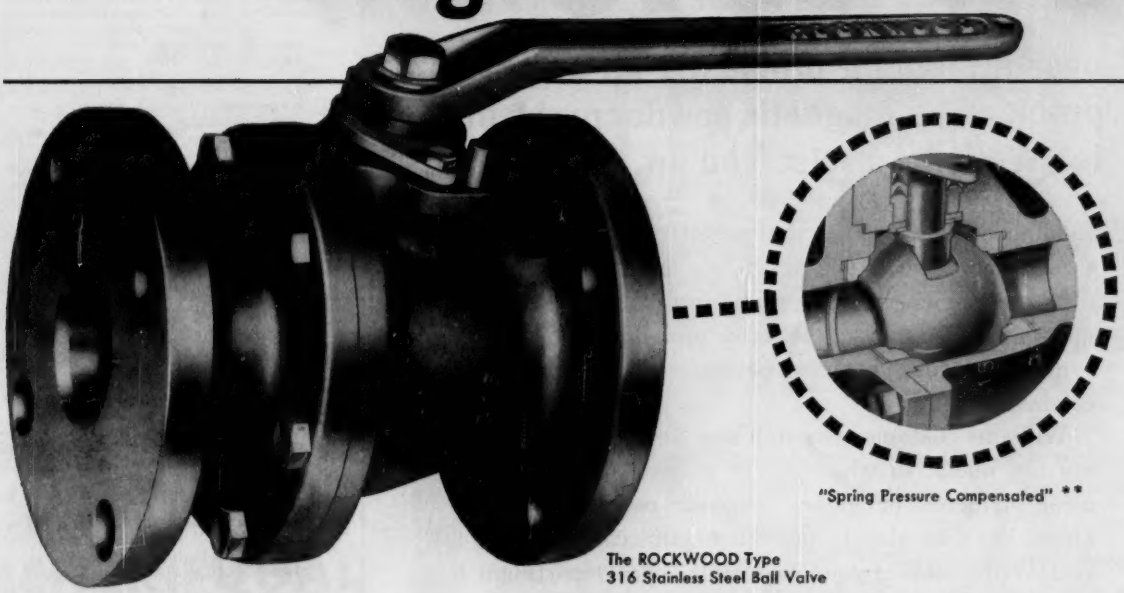
Narmco Materials Division of Narmco Industries, Inc., has established a new East Coast sales headquarters at Garden City, N. Y. Company manufactures structural adhesive systems and reinforced structural plastics materials.

J. M. Huber Corp. has opened new offices at Houston for its Industrial Products Department. Facilities will service southwestern customers in the rubber and paper industries.

The DeVilbiss Co. has moved its St. Louis factory branch to a new building in that city's Page Industrial Center.

NEW...

Today's "Tightest" and Toughest Ball Valve!



"Spring Pressure Compensated" **

The ROCKWOOD Type
316 Stainless Steel Ball Valve

Here's the new 316 stainless steel ball valve that not only gives you maximum corrosion resistance, but also *positive* assurance of leakproof service!

It's Tightest because exclusive spring rings back up its twin Teflon* seats . . . *automatically* compensate for pressure variations, wear, cold-flow deformation and temperature effects. With flow in either direction . . . under vacuum or 600 psi . . . seats always hug the ball.

It's Toughest because it's made with integrally cast flanges or screw ends. They *stay* leakproof even under constant vibration.

You get all the other ROCKWOOD features, too: smooth, full round flow; easy ¼ turn opening and closing; dead tight sealing without lubrication; and many more. For use at temperatures from −65°F to 350°F, the Type 316 can be easily modified for cryogenics applications. Always tight in vacuum service, too. Handles air, alcohols, fuel and inert gases, water glass and many other fluids. For service up to 600 psi. 4 models available. Sizes ⅜" through 2". Send coupon for complete details. Tested and listed by Underwriters' Laboratories, Inc.

*DuPont Reg. T.M. Teflon seals include seats and adjustable chevron stem packing. Also available with nylon or synthetic rubber seals.

**Patent Pending

ROCKWOOD BALL VALVES

FULL, ROUND FLOW

Distributors in all principal industrial areas

ROCKWOOD SPRINKLER COMPANY
A Division of The Gamewell Company
272 Harlow Street, Worcester 5, Massachusetts

Please send full details on the new Type 316 Stainless Steel Ball Valve

Name.....*Title*.....

Company.....

Street.....

City.....*Zone*.....*State*.....

Puzzled

over a pigment problem ? an extender problem ? a magnetic powder problem ? let Williams assist you in solving it !

In all modesty, let us say that we are the largest manufacturer of our kind in the world. We make colors and pigments of the inorganic type—natural and synthetic—the naturals by processing selected ores and minerals, the synthetics by such chemical processes as precipitation and calcination.

Williams customer research and development facilities are the finest, so when you're puzzled over a problem using pigments, extenders, magnetic powders . . . let us know. We'll be glad to put our organization to work for you. Write, stating your problem . . . to Department 62, C. K. Williams & Co., 640 N. 13th St., Easton, Pennsylvania.

Williams...the world's broadest line of its kind !

BLACKS
Pure Black Iron Oxide
Lampblack

BROWNS
Pure Brown Iron Oxide
Metallic Brown
VanDyke Brown

GREENS
Pure Chromium Oxide
Pure Hydrated Chromium Oxide

REDS
Pure Red Iron Oxide
Red Iron Oxide
Venetian Red
Cuprous Oxide

NATURALS
Raw and Burnt Sienna
Raw and Burnt Umber

YELLOWS
Pure Yellow Iron Oxide
Ochers

EXTENDER PIGMENTS
Anhydrous Calcium Sulfate
Barytes
Calcium Carbonate, Precipitated
Silica
Whiting

MAGNETIC MATERIALS
Iron Powders
Magnetic Iron Oxide

ROUGES
Glass Polishing
Metal Polishing

WILLIAMS

"Pigment Technology at its best"

CALENDAR

British Scientific Instrument Manufacturer's Assn., international exhibition and conference.
June 16-26 Moscow, U. S. S. R.

American Institute of Chemical Engineers, national meeting, Del Prado Hotel.
June 19-22 Mexico City, Mexico

Gordon Research Conference, Information and Documentation-Critical Tables and Related Topics, New Hampton School.
June 20-24 New Hampton, N. H.

American Society for Engineering Education, annual meeting, Purdue University.
June 20-24 West Lafayette, Ind.

National Inventions Conference and Exhibit, sponsored by Cleveland Engineer's Society, Cleveland Engineering and Scientific Center.
June 20-24 Cleveland, Ohio

The University of Michigan, Engineering Summer Conference, Topics in Multiphase Flow.
June 22-July 1 Ann Arbor, Mich.

Rochester Institute of Technology, Design of Experiments for the Chemical and Processing Industries.
June 23-30 Rochester, N. Y.

International Federation for Automatic Control, first international congress, sponsored by A. A. C. C.,
June 25-July 5 Moscow, U. S. S. R.

American Society for Testing Materials, annual meeting and exhibit, Chalfonte-Haddon Hall.
June 26-July 1 Atlantic City, N. J.

International Congress on Catalysts, Maison de la Chimie.
July 4-8 Paris, France

Gordon Research Conference, Polymers, Colby Junior College.
July 4-8 New London, N. H.

Pennsylvania State University, under water missile engineering seminar.
July 10-22 University Park, Pa.

Gordon Research Conference, Statistics in Chemistry and Chemical Engineering, New Hampton School.
July 11-15 New Hampton, N. H.

Gordon Research Conference, Corrosion, Colby Junior College.
July 18-22 New London, N. H.

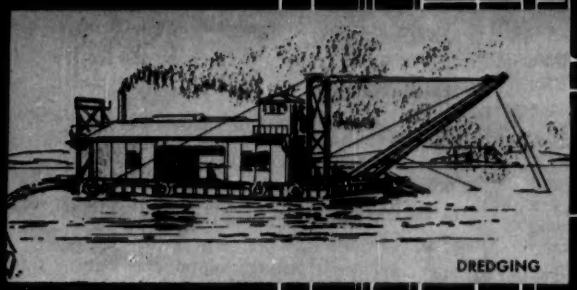
Massachusetts Institute of Technology, Dynamics and Control of Chemical Engineering Processes.
July 18-29 Cambridge, Mass.

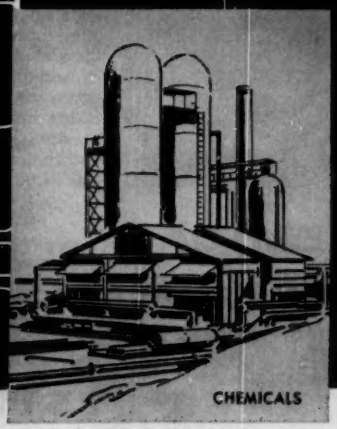
Western Packaging & Materials Handling Exposition, Los Angeles' Pan Pacific Auditorium.
July 19-21 Los Angeles, Calif.

Gordon Research Conference, Separation and Purification, Colby Junior College.
July 25-29 New London, N. H.

Gordon Research Conference, Instrumentation, Colby Junior College.
Aug. 1-5 New London, N. H.

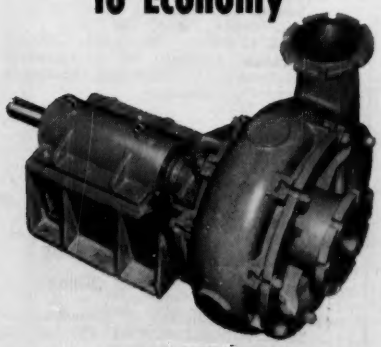
(Continued on p. 256)





MORRIS
CENTRIFUGAL PUMPS

Wherever Sustained Pumping Performance is the Key to Economy



Type CK Solids Pump. A heavy duty, low speed solids pump with extra wide clearance, designed especially to handle fluids containing random size solids and heavily abrasive materials.

If you are pumping chemical process slurries or wastes, there is a Morris Pump that will do the job dependably and economically.

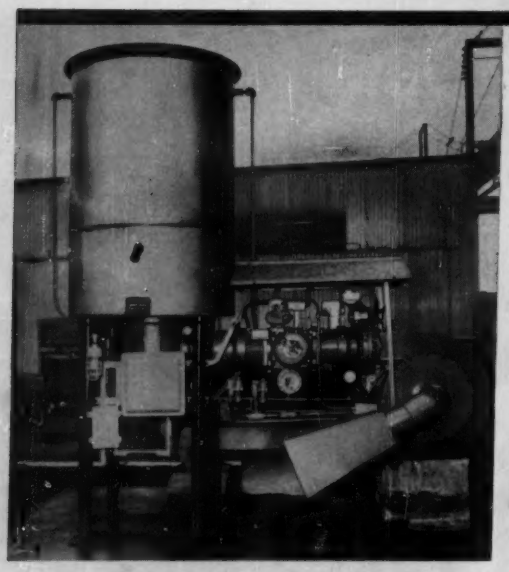
Because they are often located in inaccessible areas where service needs must be few and far between, Morris pumps are designed to operate at highest efficiency, *constantly.* Morris pump reliability is based on quality features developed during 95 years of hydraulic design and testing experience.

Field testing has evolved the most exacting engineering of component parts . . . the correct selection, forming and machining of just the right alloys for each application . . . and pumps that are rugged, long-wearing and trouble free. Every part of every Morris Pump is accessible for fast, routine service—holding preventive maintenance to a minimum.

Let the qualified Morris Representative in your area help you select the right Pump for your job. Representatives in principal cities or write direct.

MORRIS MACHINE WORKS
Baldwinsville, N.Y.

SALES OFFICES IN PRINCIPAL CITIES
EXPORT OFFICE: 50 CHURCH ST., NEW YORK 7, N. Y.



Packaged THERMAL Waste Burner System installed at The Trubek Laboratories Inc. is used to burn waste solvents and mixed aromatics. It provides automatic and complete, odor-free incineration.

SOLVE CHEMICAL DISPOSAL PROBLEMS with a THERMAL WASTE BURNER SYSTEM!

Long established as one of the most efficient heat sources available to industry, THERMAL high heat release burner equipment provides rapid, efficient, economical incineration of combustible liquid and gaseous wastes. Because of its unique design, wastes can be fed directly into the burner, eliminating the need for bulky, expensive incinerators. THERMAL installations are compact, flexible and require minimum maintenance. Efficient heat recovery can also be arranged. Find out how this system can solve your waste disposal problems. Write today for information.

THERMAL WASTE DISPOSAL SYSTEMS have proved their effectiveness with these waste materials:

GASEOUS	LIQUID
Wax kettle fumes	Acetone-Acetic acid mixture
Phosgene	Ethyl alcohol
Smelter fumes	Phenol still residues
Hydrogen Sulfide	Diethylenetriamine Tar
Plastic plant wastes	Paint & Lacquer residue
Ammonia fumes	Organic insecticide wastes
Phthalic Anhydride	Nitrated & chlorinated aromatics
Acetylene, methane & hydrogen mixture	Ethyl ether
Carbon disulfide vapors	Dimethylformamide & formic acid
	Benzene

✳ Use THERMAL's extensive lab facilities for trial burnings of your waste materials. Our engineering staff is available to do complete turn-key designs to meet your specific needs.

THERMAL

Thermal Research & Engineering Corp.

CONSHOHOCKEN • PENNSYLVANIA

REPRESENTATIVES IN PRINCIPAL CITIES

Other Thermal Products & Services:

- Gas, Oil & Combination Burners
- Heat Exchangers
- Air Heaters
- Gas Generators
- Submerged Combustion
- Combustion & Heat Transfer Equipment

CALENDAR . . .

Gordon Research Conference, Organic Coatings, New Hampton School.
Aug. 8-12 New Hampton, N. H.

Technical Assn. of the Pulp and Paper Industry, 9th Pulp and Paper Statistics Course, Brevard College.
Aug. 8-19 Brevard, N. C.

American Institute of Chemical Engineers & American Society of Mechanical Engineers, National Heat Transfer Conference and Exhibit, Statler Hotel.
Aug. 14-17 Buffalo, N. Y.

American Society of Mechanical Engineers, Heat Transistor Division Conference, Statler-Hilton Hotel.
Aug. 15-17 Buffalo, N. Y.

National Bureau of Standards, Cryogenic Engineers Conference.
Aug. 17-19 Boulder, Col.

Technical Association of the Pulp and Paper Industry, 14th Alkaline Pulping Conference, Multnomah Hotel.
Aug. 22-24 Portland, Ore.

University of Colorado, 1960 Cryogenic Engineering Conference.
Aug. 23-25 Boulder, Col.

Association For Computing Machinery, National Meeting, Marquette University.
Aug. 23-25 Milwaukee, Wisc.

Technical Association of The Pulp and Paper Industry, Forest Biology Conference.
Aug. 24-27 Seattle, Wash.

Public Health Service, Water Quality Measurement and Instrumentation Symposium, Sanitary Engineering Center.
Aug. 29-31 Cincinnati, Ohio

Air Force Office of Scientific Research, 8th International Combustion Symposium.
Aug. 29-Sept. 2 Los Angeles, Calif.

Chemical Institute of Canada, Nuclear and Radio-Chemistry Symposium, Chalk River Laboratories.
Sept. 6-8 Chalk River, Ontario

Massachusetts Institute of Technology, Joint Automatic Control Conference.
Sept. 7-9 Cambridge, Mass.

American Chemical Society, National Meeting.
Sept. 11-16 New York, N. Y.

Canadian Agricultural Chemicals Assoc., 8th Annual Meeting and Conference, Britannia Hotel.
Sept. 12-14 Muskoka, Ontario

American Society of Mechanical Engineers, Engineering Management Conference.
Sept. 15-16 Chicago, Ill.

American Institute of Chemical Engineers, National Meeting, Mayo Hotel.
Sept. 25-28 Tulsa, Oklahoma

American Society of Mechanical Engineers, Petroleum Mechanical Engineering Conference, Jung Hotel.
Sept. 26-28 New Orleans, La.

Instrument Society of America, Instrument-Automation Conference and Exhibit, Coliseum.
Sept. 26-30 New York, N. Y.

CARBORUNDUM'S TECHNICAL INFORMATION ON UNUSUAL REFRACTORIES

Data sheet

How to choose materials for

WEAR RESISTANCE

Choice of a material to give optimum wear resistance requires knowledge of type of wear (e.g. abrasion or erosion), effect on different materials, and presence of such factors as load, corrosion, thermal shock etc.

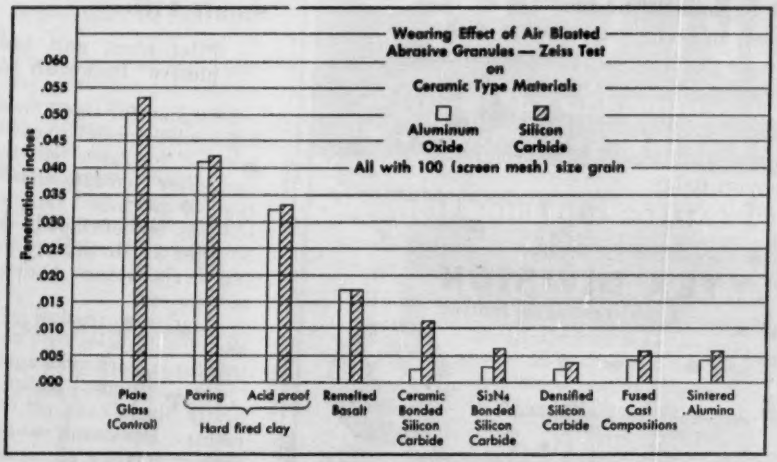
The two basic types of wear (examples shown at right) are (1) impingement of fine solids entrained in air, gas, or other fluid and (2) direct sliding of a solid mass across a surface. Effects may be erosion, primarily of the bond, thus dislodging the harder body granules; minute progressive bond fracture due to impact; or chipping, gouging or grinding of monolithic materials.

Refractories manufactured by Carborundum from electric furnace materials — such as silicon carbide and alumina — offer excellent wear resistance (see chart). Moreover, they are chemically inert, resistant to spalling, and have superior load-carrying capacity. As a result, they have found extensive use in dust collectors, gas scrubbers, transfer pipelines, hydro-cyclones, etc.

Carborundum's accumulated experience and data may help solve your wear problems. Feel free to ask for any assistance.

Abrasion by more than 2,500,000 pounds of sinter dust in 7 years has been resisted by the CARBOFRAX® silicon carbide lined cone of this primary dust collector. By comparison, other brick in the scroll and in the course between scroll and cone have been worn back to the shell, in one area after only 5 months.

Skids of CARBOFRAX® silicon carbide lasted 156 weeks under heat and the abrasion of 6¾" x 8" brass billets in this gas-fired extrusion mill furnace. Steel skids averaged only 5 weeks life.



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Information adapted from Chart 1, Carborundum **"REFRACTORIES"** Vol. 1, No. 6, December 1956. This bulletin, containing extensive technical information on the properties and application of refractory-type products, is published bi-monthly. Complimentary subscription on request.

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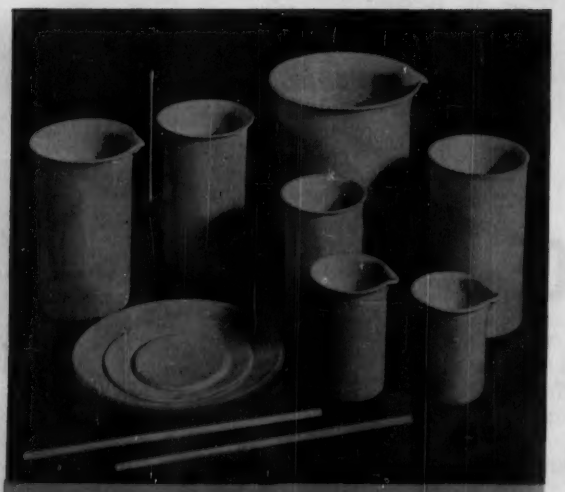

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Everything you want in your lab ware *including realistic price* is now available in the enlarged SHAMCO line. Manufactured by one of the oldest processors in the business, Shamco Teflon lab ware offers many advantages over the use of conventional ware. It is chemically inert, resists heat up to 500°F, it has good dielectric strength, won't absorb moisture, won't chip or crack, and it's unbreakable. The expanded line includes stirring rods, watch glasses, beakers, evaporating dishes, tubing, all-purpose Teflon tape, magnetized stirring bars, centrifuge tubes.

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CITY_____ STATE_____

(*Continued from page* 106)

medium is imbedded in the parent metal of the end caps to form a leak-proof seal.

Designed for 5 or more micron filtration at 15 psi., unit is 36 in. long with 2¾ in. O.D. Units are made of Monel or Inconel. Specially designed porous metal filter elements utilizing the pressure-lock process can be provided.—**Purolator Products, Inc., Rahway, N. J.** 106E

Small Filter

Pilot plant unit has "explosive" backwash feature.

Designed for small flows, new filter with special backwashing feature operates either with bare filter elements or with precoat. New filter area can be built up by continuous addition of filter aid to slurry, prolonging cycle before backwashing is required.

After upward flow of slurry has built cake to maximum thickness, backwash cycle using "pressure dome" technique literally blasts cake off filter elements. Backwash water pressure builds up air pressure in the dome at top of unit. When backwash outlet valve is opened, water rushes explosively to loosen cake.

Filter shells are carbon steel or alloy with filter areas of 14, 18, 30 and 40 sq. ft. Flow rates are 1-4 gpm./sq. ft. filter area.—**R. P. Adams Co., Buffalo, N. Y.** 258A

Venturi-Type Valve

Small throat permits use of lightweight solenoid.

A new direct-acting venturi-type valve weighs less than 2 lb. in 1 in. size. Pressure recovery characteristics of the venturi give a small throat in the valve, permit use of lightweight solenoid. Floating seal disk is self-cleaning to withstand contaminants and foreign matter.

Valves are designed for wide range of environmental conditions. Materials of construction are teflon, silicone and glass. Valve and solenoid operate from 0 to 225 psi., from −65 to 250 F.; valve can handle fluids up to 550 F. for 10 min.—**Valcor Engineering Corp., Kenilworth, N. J.** 259A

Continuous Analyzer

Sensitive instrument can read parts-per-billion.

New Flame Ionization Analyzer and Detector (FIAD) reads hydrocarbon gas concentrations as low as parts-per-billion. When used with gas chromatograph, FIAD can continuously

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The most comprehensive spray nozzle catalog ever printed. Forty-eight pages of reference data on thousands of spray nozzle designs and sizes. Provides an unequalled choice of capacities, characteristics and materials. The result of over twenty-five years of specialized research, design and manufacturing.

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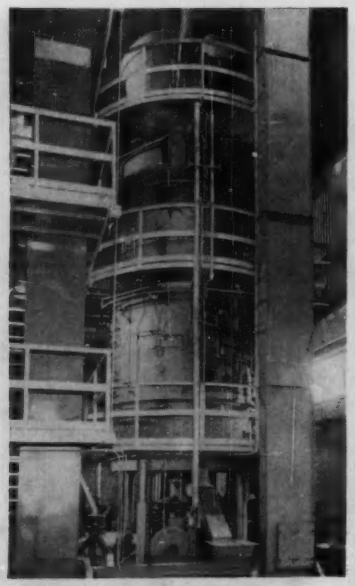

If you have a Drying, Roasting, Calcining or Decomposing problem...

a Skinner Furnace

may be the answer

Successful applications of the Skinner Furnace include:

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- Roasting Zinc Ores
- Calcining of Basic Alum, Clays, Foundry Sand, Carbon, etc.
- Incineration of Sewage

Chloridizing Roast

- Roasting Uranium-Vanadium Ores

Reduction Roast

- Decomposition of Oil Sludge
- Lime Burning
- Manganese Reduction

Drying

- Drying Uranium-Oxide Precipitate
- Drying Copper Concentrates
- Dehydration of Alunite

Many other applications are possible ***because of the flexibility in construction and operation of the Skinner Furnace...***

- 2 to 14 hearths
- 4'0" to 23'6" dia.
- 22 to 4000 sq. ft. hearth area
- Direct or indirect fired with coal, oil or gas
- Variable rate of feed and retention time
- Up or down draft
- Handles any solids... slimy, sticky, loose, coarse
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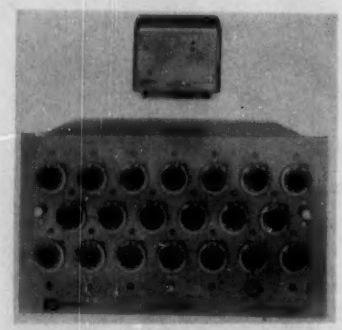
analyze for common hydrocarbon compounds.

The portable unit is battery powered, weighs only 5½ lb. It can be used for air pollution studies, combustion efficiency tests, explosive gas detection, elemental carbon and hydrogen analysis, and similar applications.

FIAD works by introducing the sample into a pure hydrogen flame, measuring the electron concentrations formed, and reporting on a carbon atom basis. Response is linear up to concentrations of 2%.—**Carad Corp., Redwood City, Calif. 259B**



Signal Detectors

Sound alarm when process signal varies from norm.

Up to 20 low-level voltages can be monitored simultaneously by new voltage detector. Companion unit acts as watch dog on current flow. When signals (thermocouple, etc.) exceed preset limits, alarm warns operator.

Solid-state electronic circuits use pulsed magnetic amplifiers to monitor input voltages. Circuits are connected to a common relay so that input voltage exceeding preset limit on any circuit will activate relay. A bulb lights to identify the channel and an external warning device is triggered. Voltage detector range is about ±20 milliamp.

Separate current detector has two adjustable set points for high and low limit. High or low current flow activates an alarm. Solid-state switches provide outputs up to 250 milliamp. at 28 v. —**Daystrom, Control Systems Div., La Jolla, Calif. 260A**

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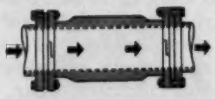
PINCH VALVES

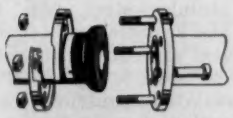
RUBBER, NEOPRENE
for Corrosion and Abrasion

- 1" to 14" inside diameter.
- Pressures to 150 psi.
- Temperatures to 200° F.
- Patented "hinged" sleeve. Recesses serve as "hinges" during compression; reduce strain and permit tight closing.

- Cannot leak or stick.
- No working parts in contact with pulp or liquid; no packing glands.



- Unobstructed flow eliminates high friction loss.
- Remote control available.
- Can be equipped for automatic regulation.



- Split flanges and patented Flex Seal ends assure perfect seal.
- Closing mechanisms... manual handwheel; handwheel with chain and sprocket reduction unit; electric worm gear motor reducer; chain operated torque arm reducer; hydraulic; air-hydraulic.

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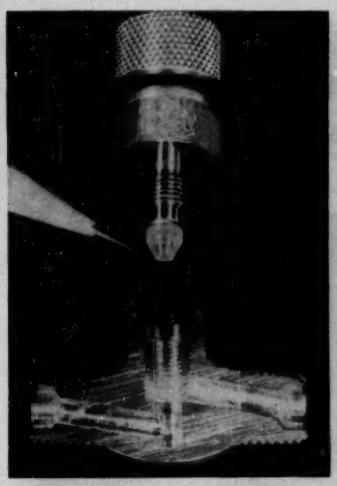


New Needle Valve

Plastic tip assures long operating life, tight seal.

Over-eager operators cannot gall the seat of new needle valve provided with plastic instead of conventional metal tip. Made of Minnesota Mining and Manufacturing's Kel-F, tip is chemically inert, can withstand 5,000 valve openings and closings at 3,500 psi. using twice normal closing force.

Now standard on the 300 series, ⅛- and ¼-in. stainless steel valves, Kel-F tip has wide operational temperature range, low cold-flow characteristics, and minimal swelling.—**Hoke, Inc., Creskill, N. J.** 261A

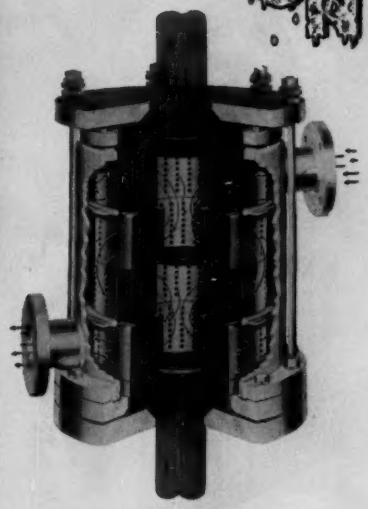
Heat Sealed Bags

Multiwall units make liquid, air-tight package.

Hygroscopic, deliquescent and semiliquid products can be shipped in multiwall paper bags with inner moisture-proof ply. Two to six plies of paper make a bag that will hold up to 100 lb. of material. Plies are made of various combinations of kraft paper, kraft and foil, or polyethylene-coated kraft and foil.

Outer plies of the bag are staggered or offset to expose inner ply for direct heat sealing. After machine seals inner plies, it applies adhesive to the outer plies, folds them over, and

BEAT CORROSION



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STACKED IMPERVIOUS GRAPHITE BLOCKS

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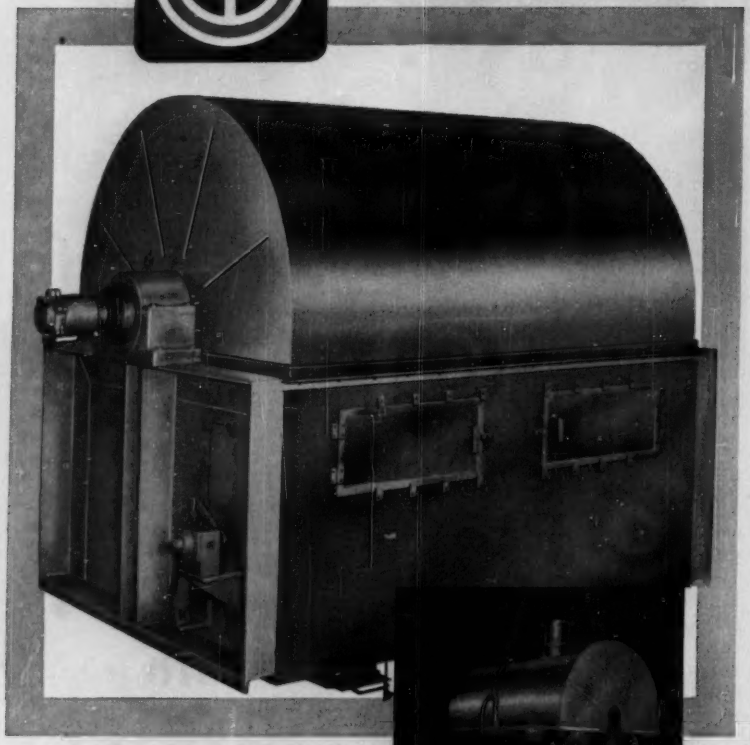

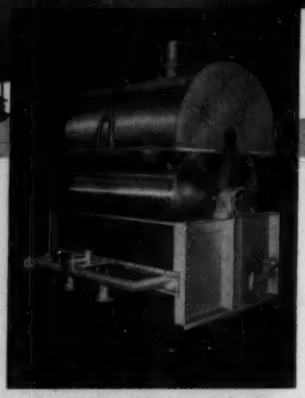

...ASSURES GREATER OPERATING EFFICIENCY

This 60" dia. x 72" flaker was designed and built for a major chemical company to convert molten organic chemicals to solid flakes. The unit features:

■ Air operated knife holder ■ Special monel construction double shell drum ■ Enclosure confines obnoxious vapors ■ Feed pan projects to rear for access to and inspection of overflow adjustment

More detailed information on this and other G-B designed and built equipment is yours for the asking.

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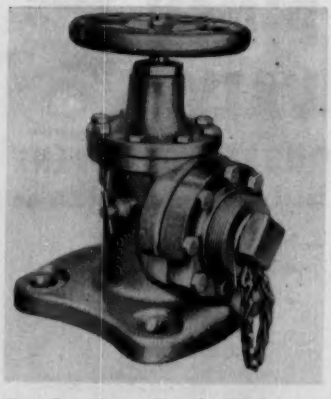
seals them to the outside of the bag. A final strip of tape applied by the machine completes the closure. Sealing machine can handle 6 bags/min.—**Union Bag-Camp Paper Corp., New York, N. Y.** 261B



Tank Car Seal Valve

Teflon V-rings provide tight pressure seal.

If packed type valves on tank cars give you trouble, here's a new packless valve using V-ring pressure for a seal. According to the manufacturer, new valve with teflon rings operates easily, shows minimum wear.

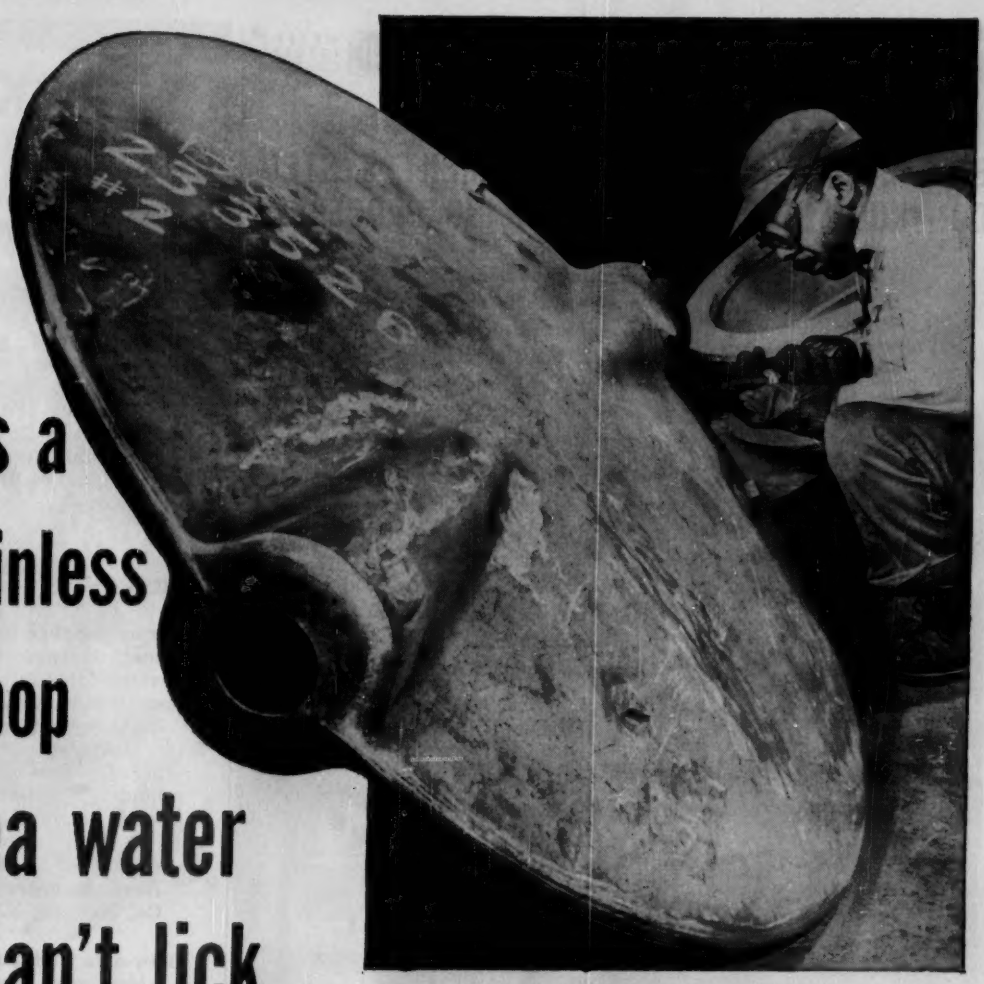
Tank pressure expanding the V-rings effects a leakproof seal around the stem. Also, the rings are spring loaded to give seal at atmospheric pressure. Valve has forged-steel body and bonnet, stainless-steel stem. Gaskets and seat disk are teflon.

A vent valve in the valve body may be used to bleed off any accumulated pressure before the outlet plug is removed.—**Bastian-Blessing Co., Chicago, Ill.** 262A

Durable Ear Plug

Triple flange construction gives complete seal.

High noise level leads to low morale and possible hearing impairment. Yet frequently chemical process equipment can't be designed to operate silently. New Com-Fit ear plug meets the



Here's a stainless lollipop sea water can't lick

This large (48" dia., 1701 lbs.) and unusual stainless casting was fabricated by Allegheny Ludlum's Buffalo, N.Y. foundry. It is scheduled for service under the most severe operating conditions, functioning as a wafer valve disc at 25 psi pressure in sea water. Since long life and tight closing are essential in this application, corrosion resistant Type 304 Allegheny Stainless was specified.

Some unusual techniques were employed in the fabrication of this casting. Although the entire valve disc was cast as a single piece, its sides are hollow, with a skin only ¾" thick. The center shaft was cast solid at the same time the side wings were cored, permitting the single piece, seamless part desired.

If you have a casting problem, or *any* problem that involves corrosion resistance, long life, resistance to wear and abrasion, call the Allegheny Ludlum Sales Office nearest you. An A-L Sales Engineer is ready to put his skills and those of the A-L Technical Staff promptly at your disposal, to serve your requirements from the largest and most complete line of stainless products on the market.

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28 pages of valuable and complete data on stainless castings: analyses, properties, technical data on handling and heat treatment, typical applications, how to order, etc.

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problem by providing inexpensive durable easy-to-use protective unit.

Plug is made of a silicone rubber which is nontoxic, is resistant to earwax and skin oils. One universal size, which fits all ear openings, makes plugs interchangeable after boiling and sterilization.

Ear plug consists of center core and three soft flanges. It is pushed into the ear opening until successively larger flange seals opening. — **Sigma Engineering Co., Los Angeles. 262B**

BRIEFS

Stormy weather is no threat to new inexpensive rainwear which folds into auto's glove compartment when not in use. Light weight protective suit —jacket, overalls, and hood— permits free action without binding, resists oils, acids, other chemicals. Flexible to –20 F., it has welded seams, reinforced button holes.— **Davis Emergency Equipment Co., Newark, N. J. 264A**

Blow-outs and pull-outs eliminated, says manufacturer of steel fittings for nylon and other plastic tubing. Available in commercial shapes and sizes, fittings feature an internal tube support and outside precision sleeve. No special tools needed for assembly.—**Flodar Corp., Cleveland, Ohio. 264B**

Model 624 pneumatic controllers, which feature modular design and high control stability, have proportional control with 1 to 400% proportional band, reset control with 0.1 to 50 repeats/min. reset rate. Only 8 x 8 x 5 in., aluminum-cased units control pressure, temperature, flow and differential pressure, humidity, or differential liquid level.—**The Bristol Co., Waterbury, Conn. 264C**

Smooth side seams on steel pails minimize lining failure caused by uneven conventional welded seam. New

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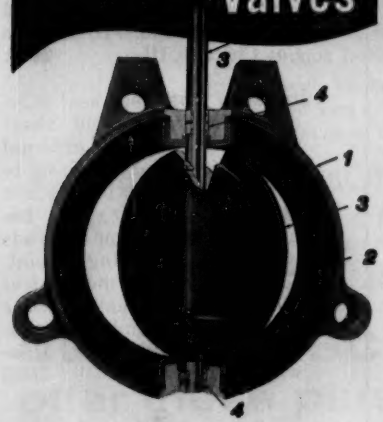
ROCKWELL *Resilient-Seated* Butterfly Valves



1 Less weight, space and cost: Valve face-to-face, overall height and weight are one-fourth to one-eighth those of gate valves. Cost less initially and are easier to install.

2 Drop-tight, leakproof closure. Resilient elastomer liner forms positive seal with disc. Liner removable on the job.

3 Disc and shaft assembly designed for highest rated pressure under most severe operating conditions; always operable manually or automatically.

4 True close bearing fit for shaft; non-leaking, non-galling, corrosion-resistant.

5 And what is quite obvious: the streamlined, self-cleaning design that eliminates cavities and voids in body; low pressure drop; no fouling. Valve can be installed in any position.

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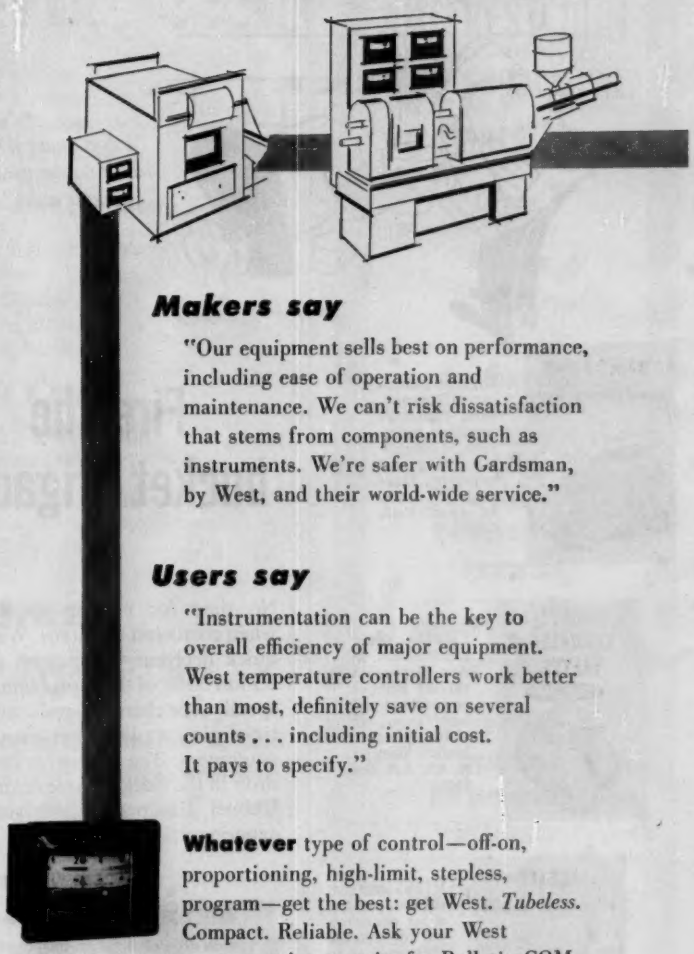

Makers say

"Our equipment sells best on performance, including ease of operation and maintenance. We can't risk dissatisfaction that stems from components, such as instruments. We're safer with Gardsman, by West, and their world-wide service."

Users say

"Instrumentation can be the key to overall efficiency of major equipment. West temperature controllers work better than most, definitely save on several counts . . . including initial cost. It pays to specify."

Whatever type of control—off-on, proportioning, high-limit, stepless, program—get the best: get West. *Tubeless.* Compact. Reliable. Ask your West representative or write for Bulletin COM.

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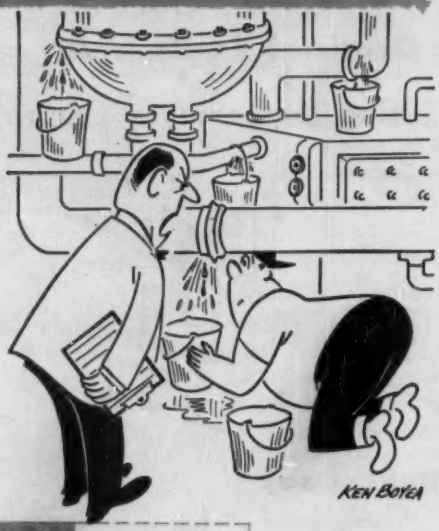

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Highest pumping efficiency, with faultless corrosion resistance. Hard rubber casing and impeller; Hastelloy *C* shaft. 80 gpm. *Bul. CE-55.*

Fire the bucket brigade!

No time for passing the bucket when corrosion threatens. With one quick decision you put an end to 85 to 100% of these problems. Just specify *Ace* chemical-resistant plastic piping and rubber-protected equipment. The long-term cost is a drop in the bucket. American Hard Rubber Company's 108 years of experience is at your service.

Liquids never touch metal in Ace diaphragm valves! Rubber or plastic-lined cast iron, or solid plastic bodies. Sizes ½ to 6". Ask for facts.

High-impact, rubber-plastic, most economical for average chemicals. ½ to 6". Screw or solvent welded fittings. Valves ½ to 2". NSF-approved. *Bul. 80A.*

All-purpose rigid PVC. Sched. 40, 80 & 120, ½ to 4". Threaded or socket-weld fittings. Valves ½ to 2". NSF-approved. *Free Bul. CE-56.*

ACE *chemical resistant equipment*
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See ACE equipment in Chemical Engineering Catalog

NEW EQUIPMENT . . .

lined pails with planished seam holds lining better, allows tighter seal on open-top model because there is no ridge on sealing surface. No extra charge for planishing. —**Bennett Industries, Inc., Peotone, Ill.** **264D**

Slide rule with special concentration and gas law scales gives quick answers to the correct decimal place. One setting of the slide solves most problems in molarity, mole and volume fraction, and pressure, volume, temperature relationships. Rule with special and standard scales costs $10.—**Dyna-Slide Co., Chicago, Ill.** **266A**

Ultrasonic vibrations seal polyester film, tape and sheet without adhesives or external heat. Joining materials up to 6 mils thick, method is not affected by coatings on the plastic, seals lapped ends without thickening joint. High frequency mechanical vibrations apparently create heat to form bond.—**International Ultrasonics, Inc., Rahway, N. J.** **266B**

Equipment Cost Indexes . . .

	Dec. 1959	Mar. 1960
Industry		
Avg. of all	237.0	237.8
Process Industries		
Cement mfg.	231.1	232.4
Chemical	239.0	240.0
Clay products	224.6	225.8
Glass mfg.	225.6	226.6
Paint mfg.	228.7	229.7
Paper mfg.	230.2	231.3
Petroleum ind.	233.6	234.7
Rubber ind.	236.5	237.5
Process ind. avg.	235.4	236.3
Related Industries		
Elec. power equip.	242.1	242.8
Mining, milling	240.4	241.5
Refrigerating	267.3	268.4
Steam power	223.9	224.9

Compiled quarterly by Marshall and Stevens, Inc. of Ill., Chicago for 47 different industries. See Chem. Eng., Nov. 1947, pp. 124–6 for method of obtaining index numbers; April 4, 1960, pp. 149-50 for annual averages since 1913.

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• Harmful	• Solid gas reacting

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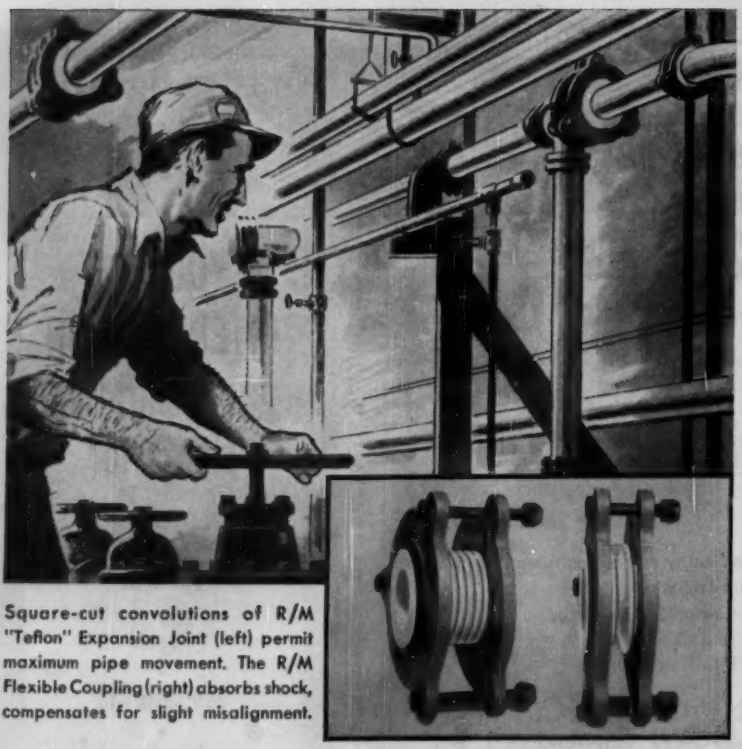

Square-cut convolutions of R/M "Teflon" Expansion Joint (left) permit maximum pipe movement. The R/M Flexible Coupling (right) absorbs shock, compensates for slight misalignment.

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TECHNICAL

For Experts

THE CORROSION AND OXIDATION OF METALS. By Ulick R. Evans. St. Martin's Press, New York. 1094 pages. $25.

Any author of a 1,094-page technical book rates a pat on the back just for quantity alone.

But Dr. Evans, with his new book on corrosion and oxidation, has produced much more than sheer volume. Obviously written by a man intimately acquainted with corrosion in all its aspects, it appears that Dr. Evans has poured his heart and mind out in this massive volume.*

This is no book for the casual reader or the corrosion neophyte. These two types of readers would be happier with Evans' earlier and well-known books "Introduction to Metallic Corrosion" and "Metallic Corrosion, Passivity and Protection."

This is a book for corrosion experts. It deals with everything from electrochemical corrosion to corrosion fatigue. In fact, it resembles Mrs. Murphy's chowder in some respects in subject matter—there's a good, practical treatment on corrosion in boilers and condensers and chapters on the crystalline structure of materials and test methods in the pure science of corrosion.

A prodigious reader of the corrosion literature, the author backs up many of his statements with references—his author index contains 3,000 names. Dr. Evans claims he has consulted nearly all his references in the original. We believe this, since his discusses each knowingly and interestingly—they are not merely dropped into the text like raisins into a cake.

It would be impossible to give the flavor of this book without quoting a few paragraphs:

"Too often the designer has not been merely ignorant of cor-

* The author, who is at Cambridge Univ., in typical British fashion, fills his book with long, rambling footnotes, some fascinating, some very, very dull.

BOOKSHELF

rosion, but has lacked interest in it. Now interest is not something which can be created at will, but it is a fallacy to imagine that something that makes no appeal to the interest can safely be neglected."

"It might reasonably be expected that with the elaborate coating systems available today, the spectre of soil corrosion would have vanished. However . . . corrosion is still a common problem."

For more, we recommend that you read the book.—RBN

For Talented Kids

CAREERS AND OPPORTUNITIES IN CHEMISTRY. By Philip Pollack. E. P. Dutton, New York. 147 pages. $3.50.

Every year nearly 3 million young Americans reach the college freshman age of 18. And too few—for their own and their country's good—go to college.

If the lack is motivation, here's a chance to steer your children, your friends' and neighbors' into our rewarding field.

It's true that this fourth of Pollack's science career books is mostly chemistry. There is a chapter, however, on chemical engineering. It is written in the same tone as the balance of the book: clear and understandable to the intelligent teenager, but without excessive glamor.

Other chapters discuss the work of inorganic, organic, analytical and physical chemists as well as that of biochemists, chemical salesmen and women chemists.

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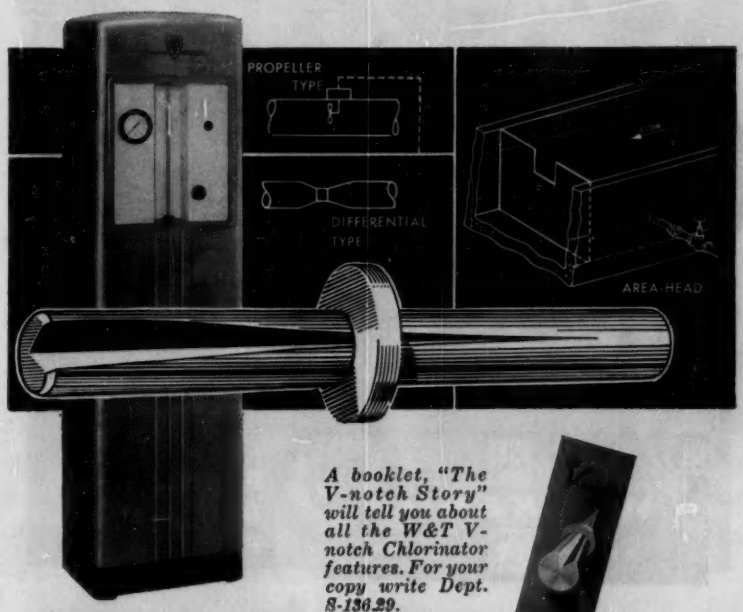

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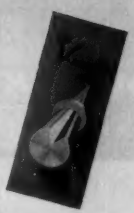

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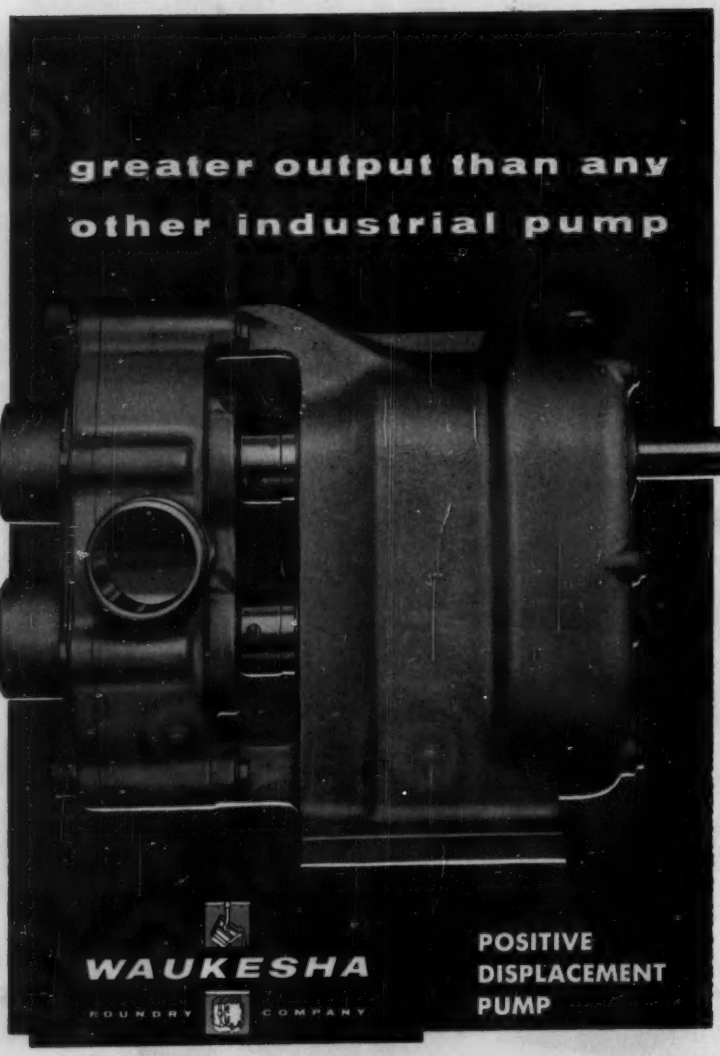

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Sir:

In your Apr. 4 issue, the photo on p. 202 was captioned: "Plastics semiworks: They work to make books obsolete."

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Haven't they heard of safety belts in plants where safety was not considered in the design?

ROBERT A. KINZIE, JR.
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Continuous Pulping Process

Sir:

Your interpretation of the University of Florida theories on continuous pulping (May 2, p. 117) is completely erroneous. You state, "Theory is that pulping reaction is independent of wood-liquor ratio."

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MICHAEL R. SHAFFER
University of Florida
Gainesville, Fla.

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Pro: Literature Scientist

Sir:

Mr. Ross's excellent article in your Mar. 21 issue on "The Information Problem" (pp. 143-148) is one of the most significant that you've printed in a long time. Mr. Ross is to be commended for a good job of highlighting the essential facts of the matter.

He correctly assays the role of the professional librarian. There is a place for machine retrieval, too, but the key man must still be the trained engineer or scientist who can separate the drivel from the facts. Let's not forget that the literature is burdened with a fair modicum of repetitive and practically useless information. Hence a high degree of selectivity based on skilled professional judgment is required.

I dare say that perhaps one-third to one-half the members of our profession are aware of and deeply concerned about the immensity and importance of the information problem. But when it comes to the high brass in government and industry, I'm firmly convinced that a large majority of them live in a never-never land of misinformation and idle technical gossip. What is worse, they apparently have rocks in their heads when it comes to facing the facts about technical intelligence methods.

I strongly doubt that we'll ever have a healthy change of attitude, especially in view of some of the recent academic blather on information retrieval which has been doled out by some of the high priests.

Of course, a major factor is the high cost of technical fact dissemination, but the decision makers aren't receptive anyway. It looks like we have an impasse which will stunt U. S. technical progress for some time to come. Meanwhile our national attitude on this question wastes millions of precious R&D dollars.

RICHARD G. ROWE
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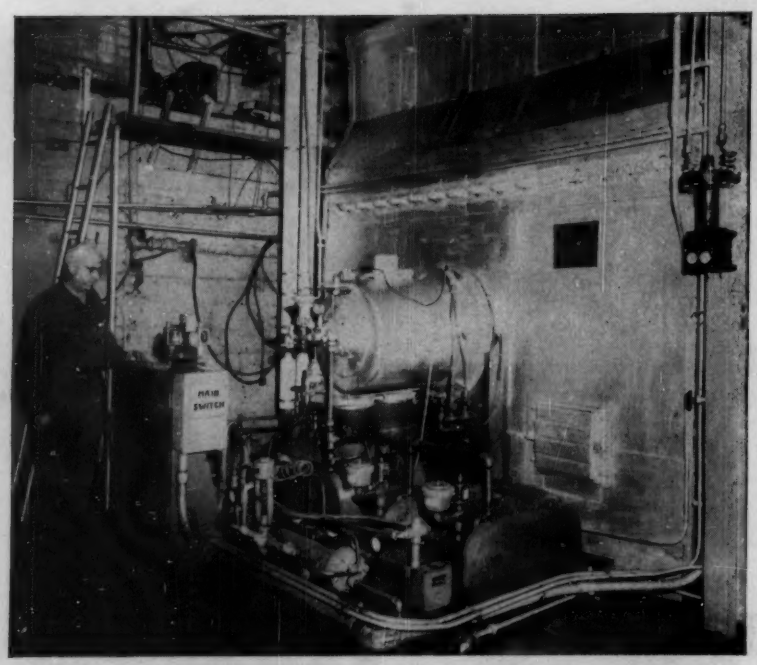

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UNRETOUCHED ACTION PHOTOS PROVE SUPERIOR PERFORMANCE OF BUELL CYCLONES

BUELL CYCLONE with Shave-Off

an ordinary cyclone

These are photographs of as true a test as can be made under laboratory conditions. Notice the difference in the dust patterns! In the Buell Cyclone, on the left, the dust at the top makes less than one revolution before it is trapped by the Shave-Off. It's then channeled down to the lower portion of the Cyclone, well below the clean gas outlet.

Why is the Buell Shave-Off so effective? Primarily because it harnesses the double-eddy current to convey the dust "fines" downward quickly, thereby promoting greatly increased efficiencies. In the ordinary cyclone, as shown on the right, these "fines" concentrate and recirculate at the top, causing erosion of the cyclone. To be collected, the fine dust must travel downward close to the clean gas outlet where much of it escapes. Buell Cyclones have made an impressive record in many years of trouble-free service. To see how their extra efficiency in the Shave-Off can pay off for you, send for our Cyclone Catalog #103. The Buell Engineering Co., Inc., 123 William Street, New York 38, New York. Northern Blower Division, 6404 Barberton Avenue, Cleveland, Ohio. (Subsidiary: Ambuco Ltd., London, England.)

buell Norblo

CYCLONES • ELECTRIC PRECIPITATORS • BAG COLLECTORS • COMBINATION SYSTEMS • FANS • CLASSIFIERS

READER SERVICE . . .

TECHNICAL

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Chemicals

Acrylonitrile.....16-page booklet describes properties, uses, handling and testing of material. Chart shows extensive reactions and derivatives from organic syntheses.
276A Monsanto Chemical Co.

Activated Aluminas.....for effective economical drying is covered in White Data Sheets & in a comprehensive Gas & Liquid Dehydration Questionnaire.
97 *Aluminum Co. of America

Activated Carbons.....for every purpose; design & prefabricate complete purification, separation, and recovery systems to meet particular needs. Bul. J-100.
R282 *Barnebey Cheney

Air Filter.....Bulletin describes how cube filters can reduce filter bank area by more than half. Data table lists capacity and resistance of various filter sizes.
276B Union Carbide Development

Antioxidant.....Performance charts and graphs in 16-page brochure illustrate effectiveness of Tenamene 3 for materials such as lubricating oils, rubber, paints etc.
276C Eastman Chemical Products

Boron Trifluoride.....Technical data on the properties and typical uses of B&A Boron Trifluoride gas or any of its complexes listed. Available now.
77 *Allied Chem., Gen. Chem. Div.

Catalyst.....New fluid cracking catalyst Aerocat 3-C is designed for more flexible & profitable refinery operation. Composed of silica, alumina & magnesia. Information.
16-17d *American Cyanamid Co.

Catalytic Oxidation.....20-page manual provides detailed data on basic engineering principles of Oxycat systems for air pollution control, waste heat recovery, etc.
276D Oxy-Catalyst, Inc.

*From advertisement, this issue

LITERATURE

E. M. FLYNN

Chemicals.....Brochure discusses the applications of MgO. Covers the areas of usage such as: electric fusion, improved magnesia blends, neutralization of acids.
277A International Minerals & Chem.

Compounds.....Drum quantities of Dialkyl Cyanamides are available for the synthesis of substituted guanidines, biguanides, normal & isoureas, thioureas, etc.
16-17e American Cyanamid Co.

Diatomite.....High bulk, irregular particle shape & large available surface area suit Celite to hundreds of mineral filler applications. Technical data offered.
113 *Johns-Manville

Dodecenyl Succinic Anhydride..... Tech. bulletin outlines physical and chem. properties plus suggested uses for material that contributes unusual properties to epoxy resin.
221D National Aniline Div.

Dyeing Agent.....Calco Leveling Salt eliminates objectionable striped or Barre effects encountered in dyeing wool carpeting. Allows colorant to dye rather than stain fiber.
16-17c *American Cyanamid Co.

Epoxy Resins.....Pamphlet describes many industrial applications with detailed explanations and photographs. Applications for effective adhesive techniques included.
277B Ren Plastics Inc.

Fertilizers.....Brochure describes Carlile processes for wet process phosphoric acid and ammonium phosphate fertilizer production. Includes schematic flow diagrams.
277C J. C. Carlile Corp.

Filter Papers.....Filtration experts can help you find the right paper for your particular requirement. Sample folder of quality E-D papers is available.
300 *The Eaton-Dikeman Co.

Fluorocarbon Resin.....Details on properties & performance of Teflon in the new bulletin on "Lined Pipe" & general information in booklet "Designing with Teflon".
127 *E. I. du Pont de Nemours & Co.

* From advertisement, this issue

Want to build up your files and keep them up-to-date? You can get any publication in this comprehensive guide — free — just for the asking.

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GRAYLOC® Seal: Leak-proof at any pressure

Leak-proof quality of GRAYLOC Seals in piping applications has been use-proved from full vacuum to 30,000 psi and test-proved up to 150,000 psi. Holding at any pressure makes GRAYLOC practical in applications requiring positive leak-proof connections.

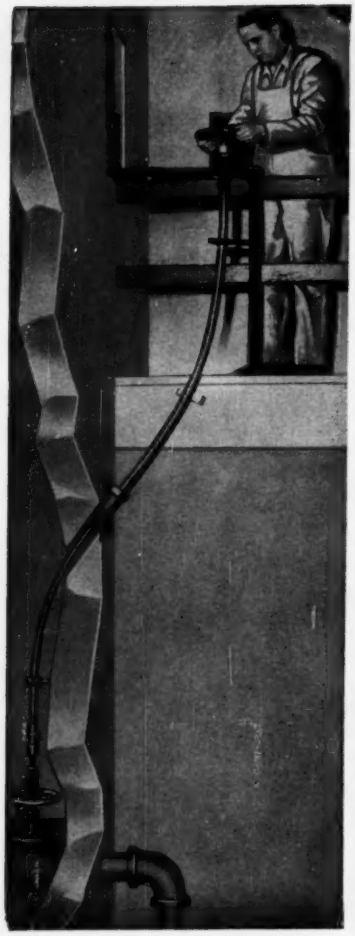
The GRAYLOC Seal is available in two-bolt clamp-type or conventional flange connections. Its simple steel design features a rigid rib with lips on either side tapering slightly less than the mating hub to form a line seal at the touchpoint. As the connection is tightened, the lips deflect to form a surface seal. GRAYLOC connections provide a permanent steel seal that can be made up repeatedly, operating to pressure without seal ring replacement. Stock connections available from ½" to 30" and on special order in corrosion-resistant metals.

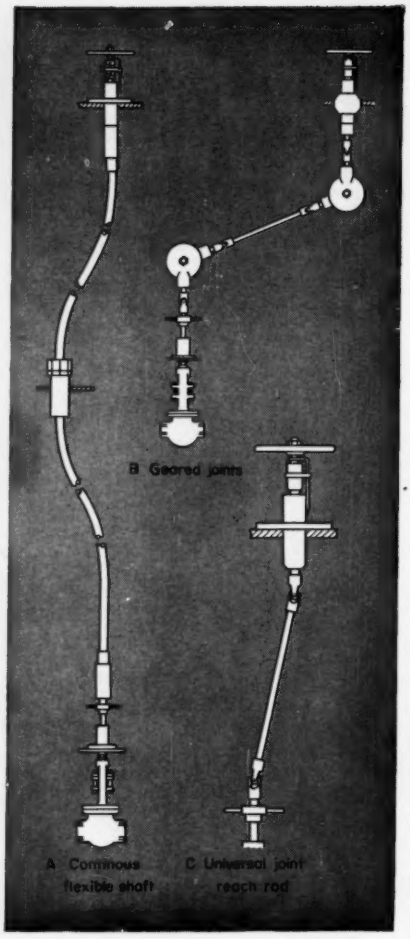
If you want to know more about how GRAYLOC Connections can permanently solve your leakage problems, write for the new GRAYLOC CATALOG on your company letterhead.

GRAYLOC SALES DIVISION

GRAY Tool Company

P. O. BOX 2291 HOUSTON 1, TEXAS Riverside 7-1240 08





Typical station arrangements

Remote control for valves

In recent years, increasing numbers of manual remote controls have been installed in industrial power plants and on nuclear reactors. These systems are popular because they eliminate a great deal of hazardous climbing and permit relatively inexpensive control of a number of widely scattered valves.

Stow Manufacturing Co. makes a complete line of these controls, including: flexible shafting, universal joints and geared joints. These controls also include standard remote stations, intermediate connections and valve couplings for both flexible shafting and reach rods.

Typical installations of this equipment are shown above. Sketch "A" shows a flexible shaft that can be used up to 100 ft. in length and is available in sizes up to 1-⅝" diameter. Sketch "B" is an installation using geared joints that operate in any angle through 340°.

For complete design data on all sizes of standard flexible shafts, geared joints and terminals, write for Design Manual 5811.

STOW MANUFACTURING CO.

121 Shear Street, Binghamton, N. Y.

LITERATURE . . .

Packing, Valve.....Thermocore (black) consists of asbestos yarns, reinforced with Inconel wire . . . braided over a plastic core of graphite & 100% white asbestos.
134b *Johns-Manville

Protective Coatings.....ranging from vinyls to epoxies to phenolics. Formulated to give maximum corrosion protection for specific applications. Technical data.
243 *Amercoat Corp.

Refractories.....Bulletin containing extensive tech. information on the properties & application of refractory-type products plus copy of "Super Refractories" offered.
257 *Carborundum

Silicone Insulated Equipment.....Motors are available now from leading motor builders. Information on what silicone insulated equipment can mean to you.
125 *Dow Corning Corp.

Stainless Steel.....Properties offered in 17-4 PH enable you to solve difficult problems in selection of metals for chemical processing equipment. New booklet offered.
130 *Armco Steel Corp.

Electrical & Mechanical

Convertible Vaportight Fixtures..... The V-51 series require only seconds to relamp or convert. Available in a variety of hub sizes in pendent, ceiling or bracket type.
1 *Appleton Electric Co.

Electric Motors.....can turn out ½ or 10,000 horsepower & meet every know job demand within this range or be custom-specified to your blueprint projections. Information.
123 *Fairbanks, Morse & Co.

Explosion-proof Lighting Equipment .....The EV series offer exactly the right fixture for any area made hazardous by flammable atmospheres of vapors or gases.
70 *Crouse Hinds

Gear-Driven Swivel Joints.....are available in 2, 2½, 3 and 4 inch sizes. Size & type to meet every requirement. Full catalog and price information.
63 *Continental-Emsco Co.

Motors.....For totally-enclosed, open-type & Super-Seal general purpose motors, & electrically or mechanically modified definite-purpose motors. Application help available.
93 *Allis-Chalmers

Motors.....1960 motor application guide outlines characteristics and includes up-to-date information on designs. Includes factors in motor selection.
280A Century Electric Co.

Motors.....Highly-effective sealing prevents entrance of moisture, dust, dirt, etc. Newest data on modern enclosed motors including explosion-proof in Bul. PB6000-2.
145 *Elliott Co.

Motoreducers.....available in horizontal, vertical & right angle types. Units available up to 75 hp; output speeds from 780 rpm down to 1.2 rpm. Bul. 3100.
45 *The Falk Corp.

* From Advertisement, this issue

STANDARDIZED
HEAT EXCHANGERS
by

M&L

A MARK OF QUALITY

Manning & Lewis engineers have developed a wide range of standardized heat exchangers that fulfill nearly all normal requirements. Selection and use of these standardized heat exchangers will save engineers valuable time, assure an economical purchase price and expedite delivery time. Investigate these and other benefits of standardized equipment by M&L, long a recognized name for quality. Write on your company letterhead for bulletin.

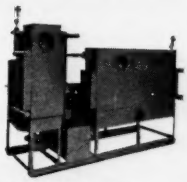
In addition, a new four-color bulletin describes and illustrates the complete M&L line. Specify Bulletin 820 in your request.

M&L **MANNING & LEWIS**
Engineering Co.
DEPT A

675 Rahway Ave., Union, N. J.

NEW DURABLE KATHABAR® SYSTEMS

offer high performance with new low maintenance for years of troublefree service



LOW MAINTENANCE

Rugged new Kathabar design provides all-nickel regenerator, separate from rest of system, to prevent condensation corrosion. Breaking all records for low maintenance, all over the world.

WIDE USAGE

Successfully applied in wide range of industries, hospitals, buildings. Easily provide conditions of 80° F and 35% RH to 30° F and 10% RH. Deliver air at -90° F dew point.

ENGINEERS LIKE

Consulting engineers like the Kathabar system: no re-heat, no frost, no chemical carryover. Humidity, independent of dry bulb, controlled with no reversing or interruption for regeneration.

GET FACTS

SURFACE COMBUSTION
A division of Midland Ross Corporation
2380 Dorr Street, Toledo 1, Ohio
Send facts on Kathabar systems for following application:

name & title .....
company .....
street .....
city ..... *zone* ..... *state* .....

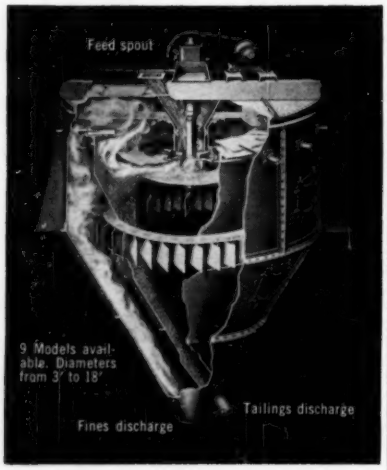
Surface

59-7

In Europe: NEDAIRCO, The Hague. In Japan: CHUGAIRO, Osaka.

Size Requirements Getting Tougher?

Sturtevant Air Separators Increase 40 to 400 Mesh Output as Much as 300%



Closed-circuit air separation is of proved advantage in reduction processes. Result is a better, more uniform product. Grinding mills perform at top efficiency, output frequently increases as much as 300%, power costs drop as much as 50%.

Precise separation of all dry powdered materials. Sturtevants currently classify sulfur, soybeans, phosphate, chocolate, feldspar, sand and aggregates, pigments, limestone fillers, flour, abrasives, plastics, gypsum, ceramics, cement and other products.

Improve screening — Sturtevant Air Separators prevent blinding by removing undesirable tailings *or* fines from screen feed loads.

Works Like Winnowing Done in a Whirlwind

Sturtevant Air Separators do a mechanical job of winnowing. Precise control of whirlwind air currents and centrifugal force results in the desired size being lifted into fines cone, oversize falling into tailings cone.

A 16 ft. Sturtevant, for example, has taken a feed rate of 800 tph, containing only a *small* percentage of desired fines, and delivered 30 tph 90% 200 mesh, recirculating the oversize through the grinding circuit.

Send for Bulletin No. 087.

STURTEVANT
MILL COMPANY
100 Clayton St., Boston, Mass.
Crushers • Grinders • Micron-Grinders • Separators
Blenders • Granulators • Conveyors • Elevators

LITERATURE . . .

Safety Switch.....Visible Blade construction are a special feature of these safety switches. The latest Safety Switch Bulletin is now available on request.
57 *Square D Company

Seal Replacement.....New mechanical seal change cuts mixer maintenance costs. Complete details on seal replacement contained in Bulletin 601.
225 *Nettco Corporation

Seals.....The Grayloc Seal is available in two-bolt clamp-type or conventional flange connections. Stock connections available from ½" to 30".
277 *Gray Tool Co.

Silicon Rectifiers.....20-page booklet tells why silicon rectifier packages offer d-c power savings to the electrochemical and allied industries. Available now.
282A Westinghouse Electric

Turbines.....Information and data on mechanical drive turbines, single stage types DP and DR, for pumps, compressors, fans, blowers, etc. given in bulletin.
282B General Electric Co.

Handling & Packaging

Conveyor.....Bulletin describes drag-type conveyor that is self-cleaning and that, manufacturer claims, will move material per hp than most conventional conveyors.
282C J. B. Ehrsam & Sons

Conveyors.....Catalog 954 describes, with photographs and diagrams, line of mechanical vibrating conveyors. Selection chart and list of other equipment included.
282D Jeffrey Mfg. Co.

Conveyors, Oscillating.....Flexmount for light-duty, Collmount for medium-duty, and Torqmount for heavy-duty service. New Book 2744 contains complete data.
12 *Link-Belt Co.

Cylinders.....Seamless or welded cylinders are made in all shapes & sizes for all services. Many advantages for high or low service. Complete facts & prices offered.
13 *Pressed Steel Tank Co.

Dry Chemical Feeders.....Full line of wide range dry chemical feeders capable of controlling a few ounces to 3000 lbs. per minute. Bulletin M-38.
269 *Wallace & Tiernan Inc.

Feeders.....Vane type can be used as air locks for pressure differentials up to 3½ lbs. Roll type where extreme volumetric accuracy without pulsation is needed. Bul.
36 *Fuller Co.

Lift Trucks.....3 New F series with new Power-Crater engine are now available. Feature many outstanding working features. Additional information in Bul. BU-640.
141 *Allis-Chalmers

Material Handling.....Full information on Airstream Conveyor Systems and how Dracco can upgrade your materials handling is available on request.
48 *Dracco Div. of Fuller Co.

* From Advertisement, this issue

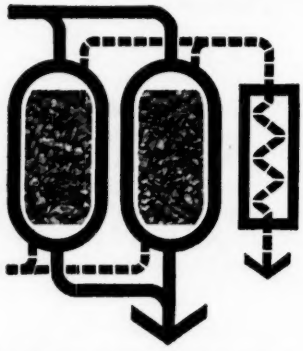
how to trap a ghost

Before solvent vapors fly out the window, many smart users literally wring them out of the air into liquid form, good as new, at costs as low as 2c a gallon—with activated charcoal recovery systems. Bonus: you may also raise worker efficiency with the right atmosphere, reduce heating costs.

how to keep your spirits

Distillers who store alcohol in barrels watch the level go down as the age goes up. Now—distillers may use activated charcoal to turn costly vapors into pure liquid form, fresh as the dew—with very attractive savings. Activated charcoal recovers many expensive vapors for as little as 2c per gallon.

activated carbon



We supply a complete line of activated carbons for every purpose; design and prefabricate complete purification, separation, and recovery systems to meet your particular needs. Write for Bulletin J-100 and recommendations on your specific application. Barnebey-Cheney, Columbus 19, Ohio.

Barnebey Cheney

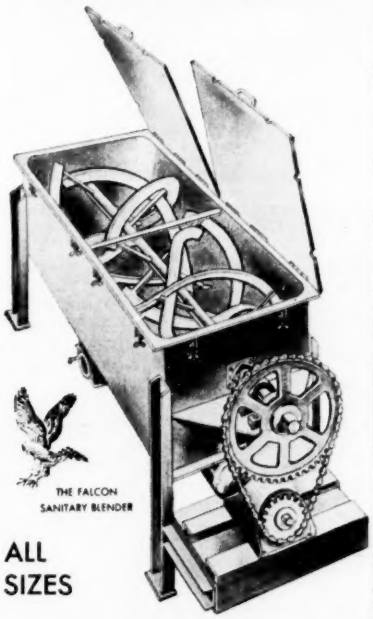
The FALCON RIBBON BLENDER
"the TOP-FLIGHT Mixer"

- POWER
- PRODUCTION
- PRICE

FEATURES . . .

- *All Welded Construction*
- *Mild Steel or Stainless*
- *Approved Sanitary Design*
- *All Rounded Corners Thruout*
- *Quickly Demounted for Cleaning*
- *Extra Heavy Shafts and Ribbons*
- *Leak Proof-Dust Tight Outlet*
- *All Sizes Usually in Stock*

MANY REPEAT ORDERS FROM PLANTS NOW USING FALCON MIXERS



ALL SIZES

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OF THE

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LITERATURE . . .

Vibratory Feeder.....Provides accurate, controlled feed of bulk materials automatically. Variable feed rate from ounces to tons. Vibratory Fact File is offered.
282E Eriez Mfg. Co.

Weighing Equipment.....features outboard bearings. Information on full line of industrial weighing equipment from 1/100 oz. to 100 ton is available.
BL 291 *Detecto Scales, Inc.

Weighing Instrument.....Flexure Plate leverage system controls processing or materials handling by weight. Literature on its application to filling, batching & checkweighing.
296 *Thayer Scale

Heating & Cooling

Air Conditioner.....Rotaspray units are self-cleaning and require no filters. Requires less than ⅛ the space of a conventional system of equal capacity.
148 *Carrier Corp.

Air Conditioning & Refrigeration..... Equipment handles loads between minus 150 & plus 100 degrees F. Booklet explains service in chemical industry.
R293 *Frick Company

Burner Systems.....Complete units for any commercial grade of fuel oil, any commercial gas (including sewer gas.) Performance data contained in Bulletin 1255.
274 *Orr & Sembower, Inc.

Furnace.....Successful applications of the Skinner Furnace include: Oxidizing Roast, Reduction Roast, Chloridizing Roast, and Drying. Many other applications possible.
260 *Mine & Smelter Supply Co.

Heater.....Hi-Turbiant has two broad fields of application; heating transfer fluids & direct firing. Bulletin HT-100 gives detailed data & shows typical system.
251 *Western Precipitation Corp.

Heaters.....Catalog 60 on general industrial heating applications. More than 15,000 different types, sizes & ratings of electric heaters & heating elements.
126 *Edwin L. Wiegand Co.

Heat Exchangers.....Polybloc heat exchangers offer high efficiency which is assured by very short passages and mixing chambers. Engineering Manual.
R261 *The Carbone Corp.

Heat Exchangers.....A new four-color bulletin describes and illustrates the complete line of heat exchangers that fulfill nearly all normal requirements. Bul. 820.
L281 *Manning & Lewis Engr. Co.

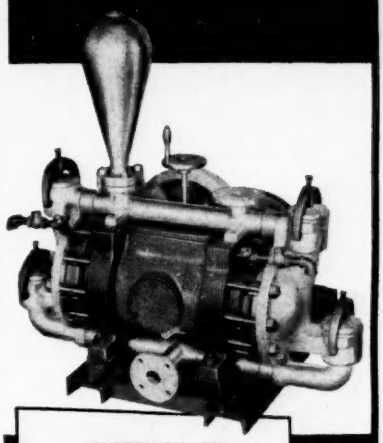
Heat Exchangers, Liquid/Gas.....for any application, alloy or size. Operating pressure: 1500 p.s.i. Additional information available on request.
54 *The Marlo Coil Co.

Heat Transfer Systems.....Liquid phase heat transfer systems if your product temperature requirements are high. Bulletin 597 gives details of Pilot Plant Series.
TL299 *Parks-Cramer Co.

* From Advertisement, this issue

for those
hard-to-handle fluids

- CORROSIVE
- ABRASIVE
- VISCOUS
- THICK
- HEAVY
- QUICK SETTLING
- VALUABLE
- SENSITIVE
- HAZARDOUS

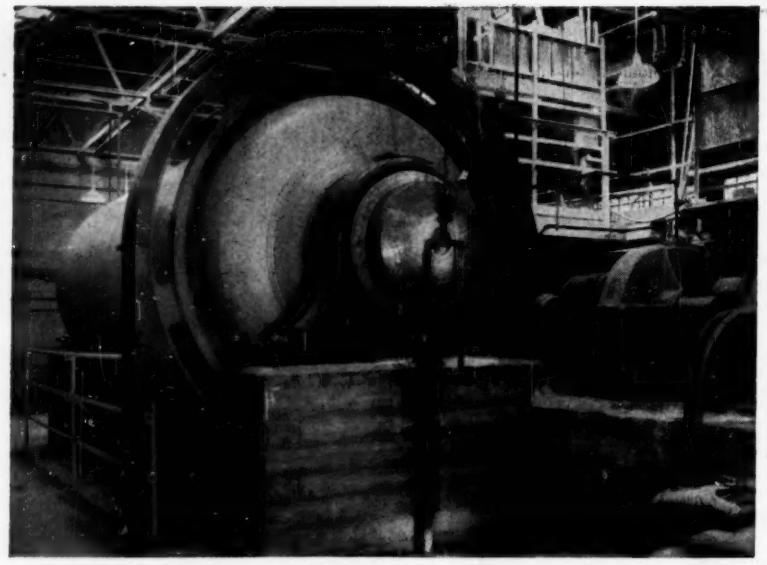


SHRIVER DIAPHRAGM PUMP

- LOW OPERATING COST
- LOW MAINTENANCE COST
- LONGER SERVICE LIFE
- EASY TO CLEAN

Thousands of Shriver pumps handling materials that clog or wear out other pumps all too quickly have proved their amazing service economy record. It will pay you to get Bulletin 148.

T. SHRIVER & CO., Inc.
802 Hamilton St., Harrison, N. J.

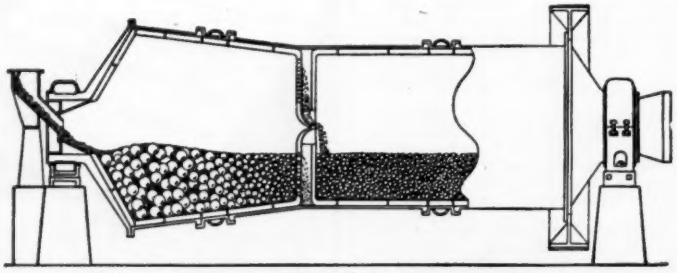


Hardinge 9' x 22' Pebble Tube Mill Wet Grinding Zircon in Open Circuit.

Hardinge TUBE MILLS...

. . . for wet grinding (in water or acid pulps)	. . . for dry grinding
Titanium Pigments	Fillers
Manganese Dioxide	Silica Flour
Diatomaceous Earth	Gypsum
Limestone	Carbon Black
	Pigments
	Cement materials

Regardless of the requirements, Hardinge Tube Mills are designed to meet specific needs. Available from 2 to 10 feet in diameter; 6 to 35 feet in length; single or multiple compartments; with acid proof lining of rubber, silica and porcelain. Complete specifications on request. Bulletin 18-B-11



Tricone compartment Tube Mill with grate and lifters.

HARDINGE
COMPANY, INCORPORATED

YORK, PENNSYLVANIA • 240 ARCH ST. • Main Office and Works

New York • Toronto • Chicago • Hibbing • Houston • Salt Lake City • San Francisco • Birmingham • Lakeland

LITERATURE . . .

High Vacuum Still.....offers stability of odor, taste and color, consistency of product and higher yields. High Vacuum Still Bulletin 3-1 offered to you.
L287 *Consolidated Vacuum Corp.

Panelcoil.....New heavy gauge embossed Panelcoil available in 5 widths from 12" to 29", in lengths up to 143". Data Sheet 15-60 Series & Price Bul. 259 offered.
TL301 *Dean Products, Inc.

Plate Heat Exchangers.....A wide range of plate heat exchangers are available for your process problems. Information on all types on request from you.
24-25a *The De Laval Separator Co.

Refrigeration.....Bulletin 631 describes the Uni-Chiller. Also if you have a refrigeration or pressure vessel application, a review of your problem is available.
R301 *The Vilter Mfg. Co.

Steam Traps.....Series 40 Trap for applications on large autoclaves, cooking kettles, heat exchangers, heating coils & other places where loads are heavy.
32 *Yarnall-Waring Co.

Instruments & Controls

Control Station.....New Electrik Tel-O-Set assures easier bumpless transfer than ever before because there's no need to "line-up" or "match" pointers. Complete details.
6-7 *Minneapolis-Honeywell

Controls.....Electronic leading-element system controls feeding and blending processes. System is completely monitored and fail-safe. Complete details.
264 *B-I-F Industries, Inc.

Controls.....The complete design data on all sizes of standard flexible shafts, geared joints and terminals is contained in Design Manual 5811 which is offered.
280 *Stow Manufacturing Co.

Controls, Temperature.....A handy, condensed catalog of the complete line of temperature controls & allied equip. for industrial heating & refrigeration.
62 *The Partlow Corp.

Flow Tubes.....Bulletin discusses new design in flow tubes for special requirements in the metering of process fluids at low or high pressures and temperatures.
284A B-I-F Industries, Inc.

Gas Flow Computer.....can be used to measure mass flow of such gases as ammonia, hydrogen, ethylene & other hydrocarbon gases, as well as hydrochloric acid gas. Details.
81 *Minneapolis-Honeywell

Instruments.....Whatever type of control-off-on, proportioning, high-limit, stepless, program. Complete information contained in Bulletin COM.
R265 *West Instrument Corp.

Magnetic Flow Meter.....has no flow restrictions of any type...nothing to plug up. Full details on the high-accuracy, low maintenance of Meter contained in Bul. 20-14.
20-21 *The Foxboro Co.

* From Advertisement, this issue

SIEMENS

INDUSTRIAL and ACID

METERS

ACCURATE

DEPENDABLE

Used for:

Distribution Batch Metering

Process Control Apportioning

SIEMENS ROTARY-PISTON METERS are currently in use in chemical processing plants on the following products:

SODIUM CARBONATE SODIUM NITRATE AQUA AMMONIA
ANILINE ACETIC ANHYDRIDE ACETIC AICID LUTIDINE
HYDROCHLORIC ACID SODIUM HYPOCHLORITE
SULPHURIC ACID SODIUM HYDROXIDE

Write for illustrated bulletin CE6

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steam process headaches
are quickly relieved
with . . .

Hi-eF

PURIFIERS

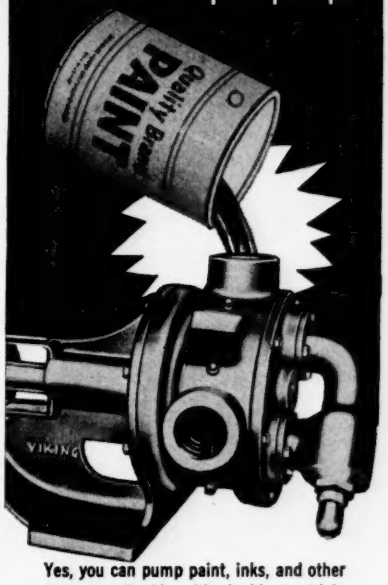
Remove damaging particles, line scale, condensate, oil from steam processes. Prevent slugs and riser discharge in evaporator and boiler service. Hi-eF separation guaranteed better than 99% efficient. No moving parts, filters or screens result in low-cost, maintenance-free performance. SPECIFICATION MANUAL 803 contains data on 13 types of purifiers, separators, mist extractors, scrubbers. Write.

THE V. D. ANDERSON CO. 1943 West 96th Street, Cleveland 2, Ohio
DIVISION OF INTERNATIONAL BASIC ECONOMY CORPORATION

Double to triple
pump life
with new

VIKING

*Abrasive liquid pumps



Yes, you can pump paint, inks, and other *abrasive liquids with double to triple pump life assured, when you install a new Viking 64124 pump. They're field-tested and proved! They're especially constructed, including ceramic bearings and mechanical seals, and suitable for *abrasive liquids from a minimum viscosity of 100 S.S.U. to the heaviest viscous types.

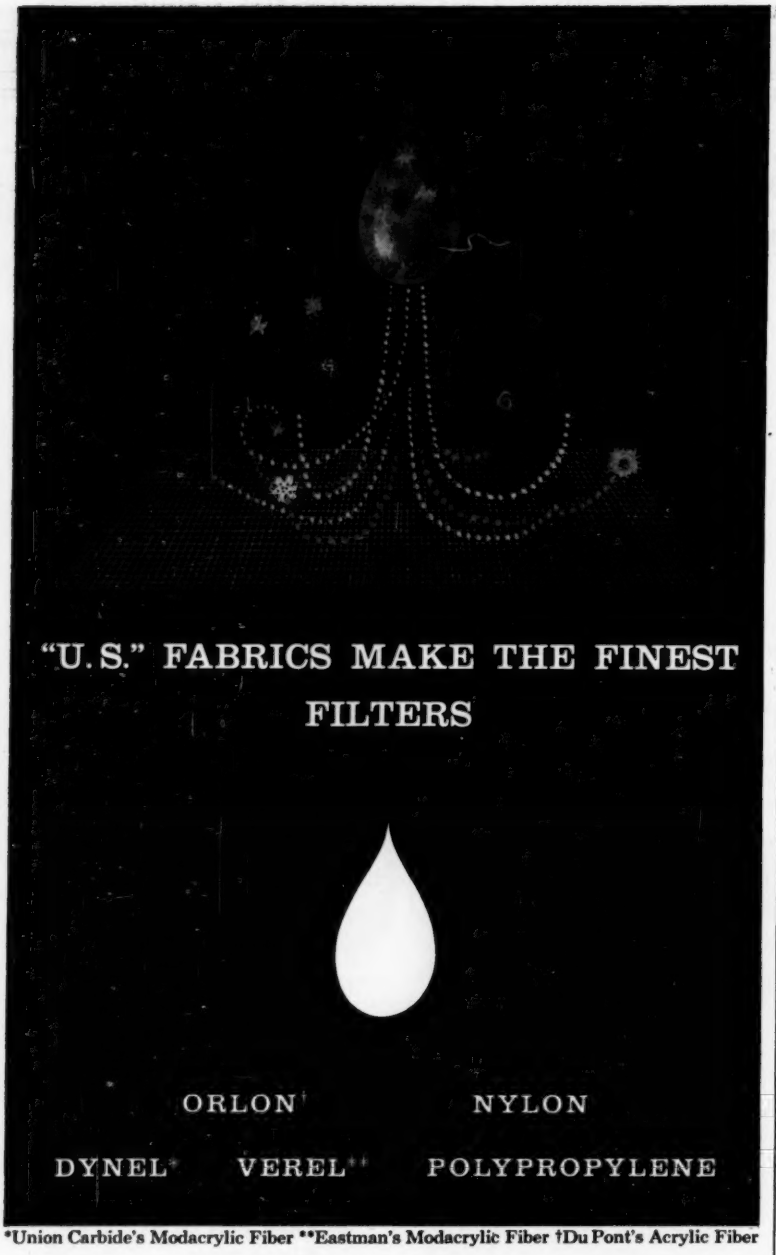
G.P.M. sizes 3 - 6 - 12 - 16 - 25 - 40
Write today, giving this information:

- Liquid pumped
- Viscosity of liquid (S.S.U.)
- Percentage and type of solids present in liquid
- Temperature of liquid
- Specific gravity
- Capacity of pump
- Suction lift or head
- Discharge pressure

Ask for bulletin series SP-507c

*Consult factory for recommendations for pumping abrasive liquids other than paints and inks.

VIKING PUMP CO.
Cedar Falls, Iowa, U.S.A.
In Canada, It's "ROTO-KING" Pumps
See Our Unit in Chemical Engineering Catalog



*Union Carbide's Modacrylic Fiber **Eastman's Modacrylic Fiber †Du Pont's Acrylic Fiber

Filter fabrics by U.S. Rubber are engineered to exacting service specifications. They offer maximum chemical and heat resistance, high abrasion resistance, and efficient cake retention-and-discharge properties. Write, wire or phone your specific requirements to Industrial Textiles Department at any of the following sales offices:

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102 N. Brand Blvd.	P.O. Box 461	1230 Ave. of the Americas
CHapman 5-5961	SKyline 4-3116	CIrcle 7-5000

Textile Division
United States Rubber

LITERATURE . . .

Meters.....Siemens industrial and acid meters are used for distribution, batch metering, process control and apportioning. Illustrated bulletin CE6.
TL 285 *T. E. A. Inc.

Metering Tubes.....New tempered glass metering tubes take up to 50% higher operating pressures. Bulletin 91-123, "The Rotameter Sheds Its Limitations" offered.
108 *Fischer & Porter Co.

Pneumatic Transmitters.....give you a true primary & transmitted signal for indication of control. Bulletins 360 & 361 can help you select transmitters & receiver gauges.
44 *Manning, Maxwell & Moore, Inc.

Reference Electrodes.....open new areas of pH control . . . in process streams up to 100 psi . . . at temperatures up to 212 F. Detailed information in Data File 14-9-06.
150 *Beckman Instruments Inc.

Thermometers.....American Bi-Metal thermometers are made of weatherproof stainless steel. The two-level "Maxivision" dial eliminates parallax effects. Catalog 100A.
114 *Manning, Maxwell & Moore, Inc.

Thermowells.....A complete line of thermowells for thermocouples, bimetallic, thermometers, & test instruments. Informative literature is offered.
TL291 *Trinity Equipment Corp.

Transmitter.....Model "P" Transmitter measures pressure & liquid level & transmits a linear 3-15 psi signal to standard receiver elements. Specifications in Bul.
311 *Conoflow Corp.

Pipe, Fittings, Valves

Expansion Joints.....Comprehensive catalogs contain information on all 3 types of expansion joints; Corruflex Packless, Ram-Pak and Slip type.
124 *Yuba Heat Transfer Div.

Pipe.....High impact rubber-plastic, most economical for average chemicals. Screw or solvent welded fittings. Valves ½ to 2". Bulletin 80A is available.
266b *American Hard Rubber Co.

Pipe.....All purpose rigid PVC in schedules 40, 80, & 120, ½ to 4". Threaded or socket-weld fittings. Valves ½ to 2". Further information in Bul. CE-56.
266c *American Hard Rubber Co.

Piping.....Fluoroflex-T piping installations offer ease of installation, decreased maintenance, long equip. life etc. Resistant to any chemical up to 500 F. Bulletin.
4 *Resistoflex Corp.

Pilot Pipe.....includes a wide range of designs that handle a wide range of working pressures from 25 to 250 lbs. & also handle a wide range of chemicals & abrasives.
241 *United States Rubber

Tube & Pipe.....Fibercast offers resistance to heat, pressure & corrosion. Free sample of Fibercast and further information about Fibercast Tube & Pipe on request.
75 *Fibercast Co.

* From advertisement, this issue.

Distill with CVC HIGH VACUUM for 1/10 cent per pound!

Process the widest range of organic and silicone compounds (from 250 to 4000 molecular weight) at today's lowest cost. That's because CVC high vacuum distillation requires lower evaporation temperatures—greatly reducing thermal hazards *and* heat input costs. This means:

Stability of odor, taste and color—you upgrade your distillates.

Separation of polymers—not possible by any other method.

Consistency of product—because you can easily draw off excess reactants and catalysts.

Higher yields—there's less product loss from decomposition or molecular rearrangement of heat sensitive compounds.

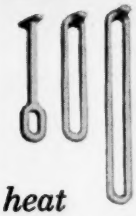
CVC Stills run virtually unattended to save you man-hours. Choose from 4 models to attain throughputs of from 2 to 4000 pounds per hour.

WRITE for High Vacuum Still Bulletin 3-1 and for information on test runs of your samples.

CVC
Consolidated Vacuum Corporation
ROCHESTER 3, NEW YORK

SHELL MOLDED PARTS

corrosion resistant


heat resistant

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- *accuracy*
- *superior finish*
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We are equipped to help you pick the right alloy for planned service conditions...We are equipped to help you design your part to take advantage of the possibilities of shell molding...We are equipped to manufacture high alloy, shell molded parts to your specifications in quantity and on time!

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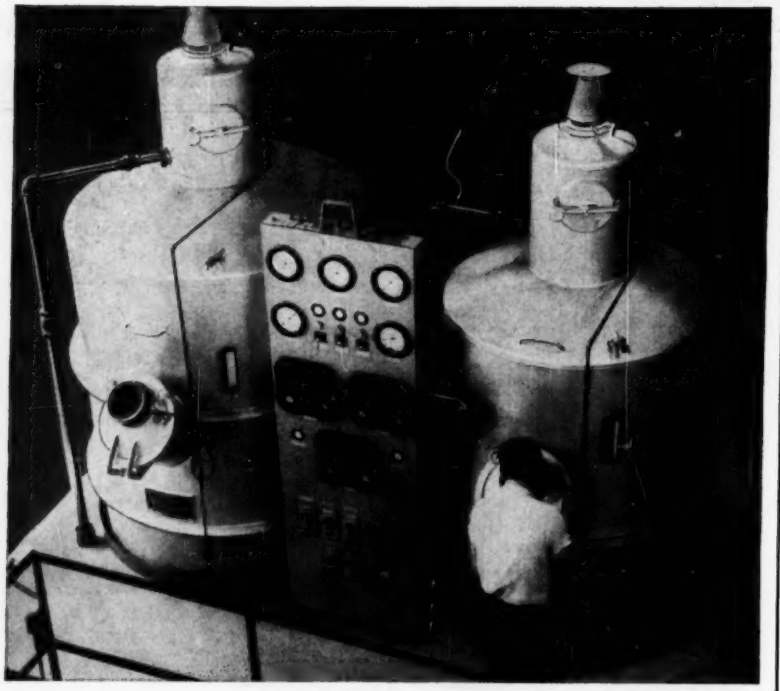
BUFLOVAK EVAPORATORS



for all chemicals...

acids, salts, pharmaceuticals, recovery of industrial waste...

Whatever your material in process may be, Buflovak Equipment will provide the way to the most profitable operation. The right evaporator, selected from a complete range of designs, can be job-tailored for your product. ■ The Buflovak evaporator line includes: Natural and Forced Circulation, Downflow, Agitated Film Roto-Vak, Crystallizers, Calandrias, Single and Multiple Effects. ■ For details, write for Catalog 372, Buflovak Equipment Division, 1551 Fillmore Avenue, Buffalo 11, New York.

Buflovak Equipment Division

BLAW-KNOX

LITERATURE . . .

Tubing.....Job-Matched stainless tubing offers you fully annealed tubes for maximum resistance to corrosion. Additional information contained in Bulletin TB-365.
156 *The Babcock & Wilcox Co.

Unions.....Cold Forged Steel Unions have the hardness differential which assures fast, easy make-up, a tight seal, and free from galling. Prices & further information.
53 *Rockwood Sprinkler Co.

Valves.....Flex Gates, a new line of 150- and 300-pound steel valves can be used on steam, water, gas, oil or oil vapor service. Full information on request.
27-29 *Crane Company

Valves.....The Eccentric Valve with Viton-covered plug, will close tight & last longer on high-temperature corrosives. Temperature resistance extends range.
158 *DeZurik Corporation

Valves.....Type F are available flanged or screwed, in sizes from ½" to 6". 2 or 3 way design, 150 psi and 300 psi ratings. Informative Bulletin V/4b.
239 *The Duriron Co., Inc.

Valves.....Nine new flanged & forged steel Gate, Globe & Check valves with hard faced seats are available. Interchangeable parts. Literature offered.
160 *Henry Vogt Machine Co.

Valves.....Non-lubricated Ball Valves feature Teflon stem gaskets & seats. Sizes ½" through 6". Regular port valves up to 8" x 6". **Catalog 1000** is available.
49 *W-K-M Div. of ACF Industries

Valves, Ball.....feature full port openings, straight through flow pattern and no turbulence. Valves go "on stream" in minutes. Bulletin BVF offered.
85 *Cooper Alloy Corp.

Valve, Ball.....Full details on the new Type 316 Stainless Steel Ball Valve. For services up to 600 psi. 4 models available. Sizes ⅜" through 2".
253 *Rockwood Sprinkler Co.

Valve, Ball.....available in injection molded UPVC for up to 150 F. & in "Penton" for service up to 225 F . . . in socket, threaded or flanged ends. Bul. TTP 180.
TL295 *Tube Turns Plastics, Inc.

Valve, Ball.....The Econ-O-Miser is available from ¼" through 6" size range & is ideally suited to difficult media because of its smooth round flow & quarter-turn operation.
135 *Worcester Valve Co., Inc.

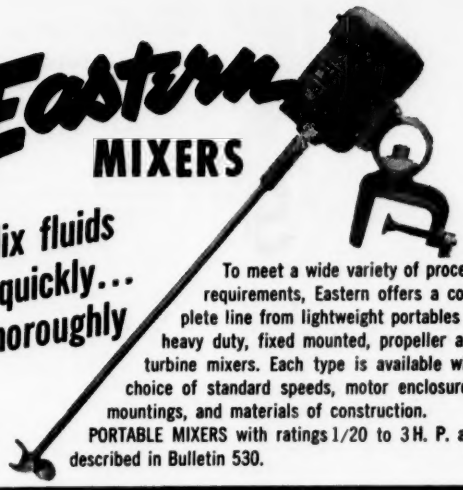
Valve, Butterfly.....features true close bearing fit for shaft; non-leaking, non-galling, corrosion-resistant. Bulletin 590X gives all the powerful facts.
L265 *W. S. Rockwell Co.

Valves, Control.....feature positive shut-off, non-turbulent flow, low operating thrust, self purging, etc. Resistant to erosion & abrasion. Tech. Catalog GV101.
R299 *General Kinetics Corp.

Valves, Diaphragm.....are available in a wide range of body, lining and diaphragm materials to meet your particular service conditions. More details on request.
58 *Grinnell Co.

*From advertisement, this issue

Eastern MIXERS



Mix fluids quickly... thoroughly

To meet a wide variety of process requirements, Eastern offers a complete line from lightweight portables to heavy duty, fixed mounted, propeller and turbine mixers. Each type is available with choice of standard speeds, motor enclosures, mountings, and materials of construction.

PORTABLE MIXERS with ratings 1/20 to 3 H. P. are described in Bulletin 530.

SIDE ENTERING MIXERS

Handle the extra heavy-duty jobs in big tanks. Sizes ¼ to 30 H. P. Send for Bulletin 620.

TOP ENTERING MIXERS

Designed for heavy-duty applications requiring agitators from ¼ to 10 H.P. Send for Bulletin 620.

TURBINE MIXERS

Range of ¼ to 40 H. P. solves many special mixing problems. Send for Bulletin 1210.

EASTERN INDUSTRIES, INC.

Mixer Division, Dept. I, Norwalk, Connecticut

PRATER ROTARY AIRLOCK FEEDERS

for

DUST CONTROL and PNEUMATIC CONVEYING

Write for "How to Select A Rotary Airlock Feeder" Bulletin P58

the recognized LEADER

FOREMOST BUILDERS OF ROTARY AIRLOCKS

PRATER PULVERIZER COMPANY

1517 South 55th Court — Chicago 50, Illinois

What's News in Milling?

"KNOW-HOW" MAKES A BIG DIFFERENCE, TOO!

In chemical milling operations two things have to be right for best results—

1. The equipment
2. The way it is used

The overall thing that ties them both together is "know-how".

What's so new about that?

Nothing, except that Morehouse-Cowles representatives continuously run into cases where one or both are wrong. And then the news is bad—quality and volume suffer, costs skyrocket.

Because of the "know-how" gained from broad experience with the most popular mill of its type on the market, they have been able to produce spectacular improvements in many instances. Production rates are being upped from 2 to 10 times on products like these—

- **Ceramic Materials**
- **Chemicals**
- **Chocolate Products**
- **Coatings**
- **Confectionery Fillings**
- **Cosmetics**
- **Fertilizers and Insecticides**
- **Food Pastes**
- **Greases & Lubricants**
- **Mustard**
- **Paints, Varnishes, Etc.**
- **Paper Coatings**
- **Peanut Butter**
- **Petroleum Products**
- **Pharmaceuticals**
- **Printing Inks**
- **Textile Dyes & Finishes**
- **Tobacco Products**

and hundreds of other products requiring grinding, dispersing, mixing, emulsifying, homogenizing, disintegrating.

If your product requires milling, it may pay you well to consult with a Morehouse-Cowles milling expert. New Super Series Morehouse Mills plus the most "know-how" have brought about a new day in milling.

Write us today about your problem.

MOREHOUSE COWLES

MOREHOUSE-COWLES, INC.

1150 San Fernando Road
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Representatives in Principal Cities
Convenient Lease and Time-Payment Plans

Please send me information on use of Morehouse Mills in processing (product).....

.....

Name..... Title.....

Firm.....

Address.....

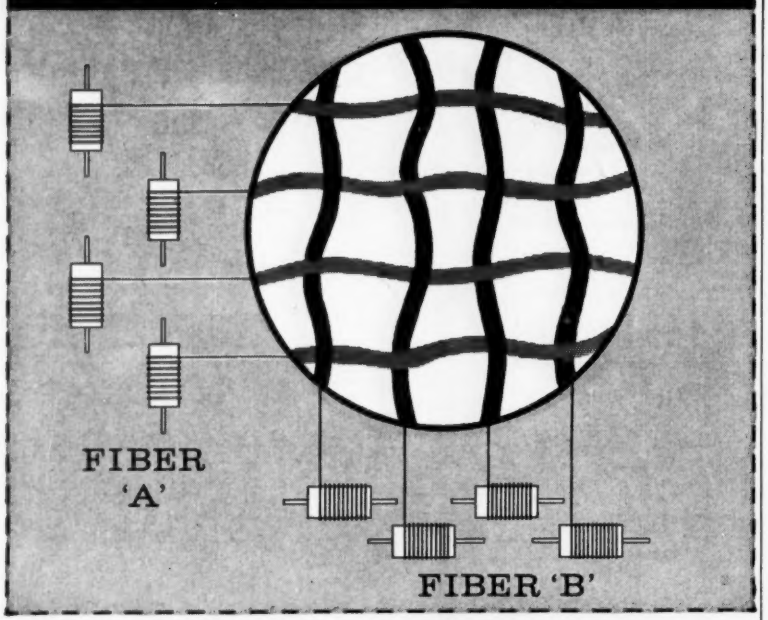
City..... Zone.... State.....

614

FOR IMMEDIATE RELEASE

COMBINATION FABRICS

created for the TOUGHEST filtration problems!



SUPERIOR ABRASION RESISTANCE, GOOD CAKE PICK-UP AND RELEASE

Now NFM blends a combination of required performance qualities into custom fabrics to fit any specific filtration process. *Example:* for rugged strength and easy cake discharge, we take smooth filaments of linear polyethylene or PVC as the warp, and weave them with filling yarns of spun or staple dynel or orlon for good cake retention. The variety of available hyphenates (PVC-dynel, linear polyethylene-dynel, linear polyethylene-orlon, and similar combinations with polypropylene) permits the looming of fabrics to any desired formula of tensile strength, abrasion resistance, heat tolerance, chemical resistance, cake retentivity and release. This flexibility in combining yarn characteristics means you can specify an NFM cloth that answers your difficult filtering problem most efficiently and economically.

Tell us your application, we will send you samples

Weavers of Industrial Filter Media for over Fifty Years

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Chicago, Illinois, 6034 N. Cicero Avenue
Maquinaria Minera e Industrial, S.A., Mexico, D.F., Apartado #215
Houston, Texas, 1607 Jefferson Avenue

LITERATURE . . .

Valves, Lubricated Plug.....a complete line available in sizes from ½" to 36" and pressures to 15,000 lbs. Additional information on request.
34-35 *Rockwell Mfg. Co.

Valves, Pinch.....with 1" to 14" inside diameter, pressures to 150 psi and temperatures to 200 F. Cannot leak or stick. Remote control available. New Catalog.
L261 *Mine & Smelter Supply Co.

Valves, Stainless Steel.....Catalog No. 59SS covers the outstanding features of these valves. Satisfy the requirements of practically any type of service.
120 *Jenkins Bros.

Valves, Solenoid.....made of all Teflon are ideal for critically corrosive applications & where long life is essential. Complete technical data.
235 *Valcor Engineering Corp.

Process Equipment

Agitators & Mixers.....Turbine-type propeller (to 120" in tanks to 50" dia.) slow speed, high speed, air lift, vertical turbine mixers, mixer-settler units. Bul. A2-B2.
297a *Denver Equip. Co.

Air Separators.....prevent blinding by removing undesirable tailings or fines from screen feed loads. Do a mechanical job of winnowing. Bulletin No. 087 for details.
L282 *Sturtevant Mill Co.

Attrition Scrubbers.....High power input to efficiently remove sand coating, mix dense slurries. Rubber lined or acid-proof tanks. Sizes to 56". Bul. A-8505.
297b *Denver Equipment Co.

Ball & Rod Mills.....offer operation & convertibility. Wet or dry grinding systems. Sizes to 10' x 20'. All steel construction. Bulletin B2-B20 offered.
297c *Denver Equip. Co.

Centrifugal.....Low compact design and exclusive Center-Slung suspension enable Batch-O-Matic to handle greater out-of-balance loads with minimum vibration. Details.
249 *American Machine & Metals Inc.

Centrifugal, Pressure.....HS 40 W Universal Pressure Centrifugal is engineered for normal operation at 1000 times gravity & internal pressures to 150 psi. Specifications.
61 *Baker Perkins Inc.

Centrifuge.....The new SRG 214 Hermetic centrifuge is capable of operating at pressures up to 125 psi and higher where necessary. Further information on reguest.
24-25b *The De Laval Separator Co.

Classifiers.....Syncro-Matic Screen Classifiers can handle soft foodstuffs, abrasive crystals, dry granules, liquids or slurries. Details on request.
24-25c *The De Laval Separator Co.

Continuous Centrifugal Separation..... built in seven sizes, each with twenty-five variations in design to custom fit the job. Specific information available.
2 *Bird Machine Co.

* From Advertisement, this issue

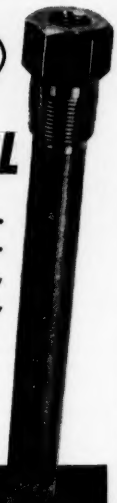
TRINITY announces the latest addition to the industry's most complete line of THERMOWELLS... the

TRINITY

ECONO-WELL

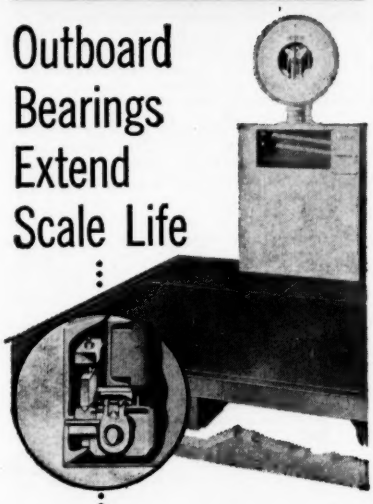
A complete line of low-cost, high-quality thermowells for thermocouples, bi-metallic, thermometers, and test instruments.

Write for Literature



TRINITY
EQUIPMENT CORPORATION
CORTLAND, NEW YORK

Outboard Bearings Extend Scale Life

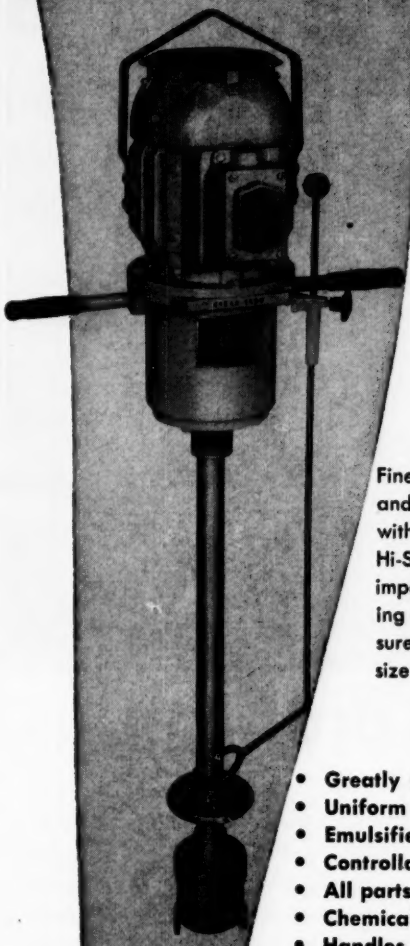


Only DETECTO gives you OUTBOARD BEARINGS!

Write for information on full line of industrial weighing equipment from 1/100 oz. to 100 ton:

Detecto Scales, Inc., Dept. C-3
540 Park Ave., Brooklyn 5, N.Y.

SHEAR-FLOW



the modern mixer with power shearing

Finer, faster blending, dispersing and homogenizing is now possible with Shear-Flow's new Model RL Hi-Shear Head. Finely spaced dual impellers induce considerable shearing action and high pumping pressures that rapidly reduce particle size for superior material mixtures.

- Greatly reduces mixing time
- Uniform circulation—no vortex
- Emulsifies immiscible liquids
- Controllable flow pattern
- All parts stainless steel
- Chemically inert seals
- Handles viscous materials with ease
- No operating Torque
- Disperses, blends, homogenizes

SHEAR-FLOW
GABB SPECIAL PRODUCTS INC.

GABB SPECIAL PRODUCTS INC.
Windsor Locks, Conn.

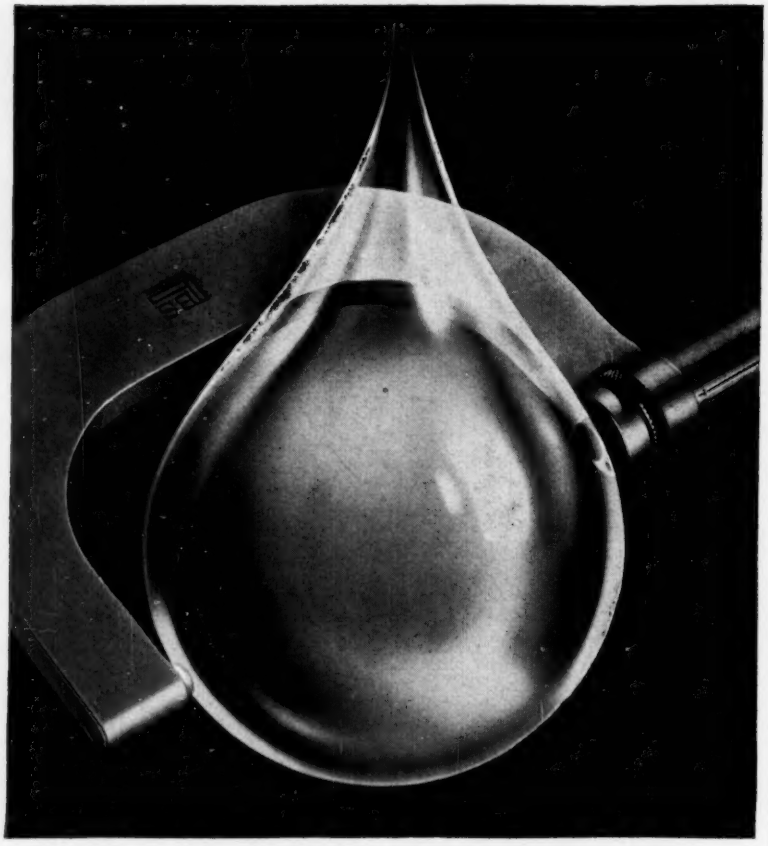
☐ Have representative call
☐ Send more information

Name _____

Position _____

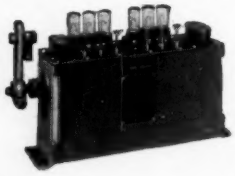
Co. & Address _____

How ACCURATE



can an oil drop get?

Precise and punctual is the best way to describe an oil drop metered by a Manzel force-feed lubricator. Model "82", for example, will deliver an exact amount of oil exactly where it belongs at exactly the right point in the cycle of your mechanism. The positive sight feed shows you the oil on its way to work *after* it's passed through the pump. Our Model "82" is built for pressures up to 6000 PSI and "round the clock service"! For details on "82" or any of our complete line of lubricators, write for our catalog. Manzel, 250 Babcock Street, Buffalo 10, New York. To lubricate with mathematical precision, just



ask the man from

UNIT OF HOUDAILLE INDUSTRIES, INC.

Manzel

SPECIALISTS IN LUBRICATORS AND METERING PUMPS SINCE 1898

LITERATURE . . .

Crushers.....Bulletin on "How To Select a Crusher" describes the various kinds of mechanical reduction, & the types of Pennsylvania crushers that supply each one.
121a *Pennsylvania Crusher

Cyclones.....Shave-Off harnesses the double-eddy current to convey the dust "fines" downward quickly. Cyclone Catalog No. 103 has additional information.
276 *The Buell Engineering Co., Inc.

Discs.....Material in process can be viewed continuously. Binder is unnecessary in many cases. Bulletin No. 247 covers all the features & applications.
BL267 *Dravo Corporation

Dryer.....The vertical, continuous Turbo Dryer is available both for indoor or outdoor use. Packaged units up to 360 sq. ft. net. Field units up to 18,000 sq. ft. net.
TL267 *Wyssmont Co., Inc.

Dust Control.....Bulletins F-75 and G-579 contain helpful planning information and air engineering data about dust filters for your particular application.
244 *The Day Company

Evaporators.....the line includes: Natural & Forced Circulation, Downflow, Agitated Film Roto-Vak, Crystallizers, Calandrias, Single & Multiple effects. Catalog 372.
288 *Blaw-Knox, Buflovak Equip. Div.

Filter.....Details on how custom engineered Niagara Filters can help with your processing problems is contained in Bulletin NC-457 which is now available.
248 *American Machine & Metals, Inc.

Filters.....Information on FEinc Rotary Vaccum Filters, FEinc String Discharge Filters and other FEinc types is contained in bulletins that are available.
246 *American Machine & Metals Inc.

Filtration.....Solka-Floc offers many advantages as a filter-medium in many processing applications. Easy & economical to use. Facts folder available.
271 *Brown Co.

Filtration.....New porous ceramic filter element has been the solution to may difficult filtering problems involving heat resistance, mechanical strength, etc. Information.
66 *Commercial Filters Corp.

Flakers.....feature air operated knife holder, special monel construction double shell drum, etc. More detailed information on this & other process equipment.
262 *Goslin-Birmingham Mfg. Co.

Floats, Stainless Steel.....New booklet includes construction data, application information, shape specifications weight tables, buoyancy formulas, etc.
TL297 *Chicago Float Works

Gyro-Shaker.....All-metal dust-tight unit scalps at high capacity, combining speed, reliable operation and efficiency. Additional data in Bulletin 160-A.
312a *Sprout Waldron & Co., Inc.

Jaw Crusher.....Cast steel frame, anti-friction side bearings & bumper bearings. Manganese steel jaw and check plates. Bulletin C12-B12.
297d *Denver Equipment Co.

*From advertisement, this issue

. . . one of a series presented by Western Supply Company, Tulsa, to improve the "I.Q."* of engineers . . . (*"Income Quotient")

TRAINED SPECIALISTS VITALLY IMPORTANT IN PROCESS ENGINEERING AND ESTIMATING . . .

The rapid, even meteoric development of the petro-chemical industry in the past decade has enhanced the role of importance played by engineering specialists with each step of its progress. Today, the engineer who is equipped with knowledge, study, training and experience in some specific phase of the processing cycle finds himself in an extremely favorable position and nowhere is this more obvious than in the realm of process engineering and estimating.

But industry has a new concept of a "specialist" in the complex of today's business society. He must have a broad concept of the total effort of his company, and cannot be content simply with "doing his job better than anyone else can." Since companies today, large or small, see their profits shrink as costs increase, the engineering specialist must apply his special knowledge or skill to the task at hand with diligence and genius, but with a practiced eye on the effect of his specialty on the profit structure of his company (or his client, or customer, if he is a consultant or supplier).

A generation ago, the "all-round" process engineer was himself a specialist, experimenting, researching, studying developing—combining "educated guessing" with engineering judgment to solve the problems presented. His was the task of dealing with all phases of an engineering process — design, estimating, operating — material and heat balances, temperatures, pressures, flow quantities, the design of special equipment, specification of instruments and controls, stress analysis, corrosion control, etc., etc.

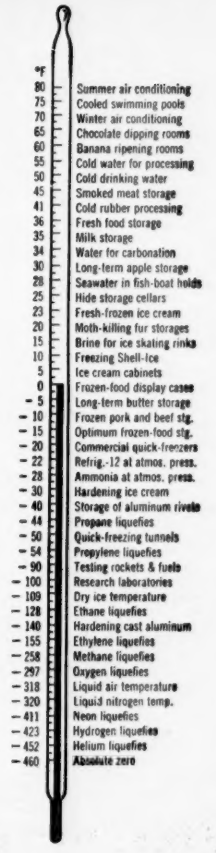
Today, with larger, more complex plants — especially in continuous flow processes — and with greater expense involved in more complicated processes, many specialties have grown from the earlier process engineer specialist, resulting in accelerated advances in each specific field, as demands for more rapid progress are met. The petro-chemical industry in particular has demanded, attracted, developed — and paid for — men of unusual ability and broad vision, expert in their specific fields, communicative, articulate, aware and appreciative of the problems of other specialists as well as of business in general — and therefore more "profitably productive" for their companies. The search for these men increases with each new demand on the industry.

What training, background, experience is needed by today's process engineer to become a specialist? What is required in addition to an extraordinary interest and aptitude for a specific phase of engineering? There are certain technological requirements related to each field, of course, and they are fairly well-defined in each phase, but there are other more general, yet equally important, qualities and attributes on which the aspiring specialist must pass muster.

Space limitations in this column do not, of course, permit a full treatment of this important subject, but it has been covered more completely and in greater detail in a booklet entitled "Engineering Specialties: A Challenge," and complimentary copies are available to you by writing to: WESTERN SUPPLY COMPANY, HEAT EXCHANGER DIVISION, P. O. BOX 1888, TULSA, OKLA. — and remember, our engineers specialize in designing, estimating and building the heat exchangers in your future.

Chemicals . . . cooling . . . and FRICK dependability

Synthetic rubber reactors handle batches two or three times as fast when cooled with Frick direct-expansion coils. This battery is in the American Synthetic Rubber Corporation plant, Louisville, Ky. Write for this free booklet that explains in detail how Frick is serving all branches of the chemical industry.


°F
80 Summer air conditioning
75 Cooled swimming pools
70 Winter air conditioning
65 Chocolate dipping rooms
60 Banana ripening rooms
55 Cold water for processing
50 Cold drinking water
45 Smoked meat storage
41 Cold rubber processing
36 Fresh food storage
35 Milk storage
34 Water for carbonation
30 Long-term apple storage
28 Seawater in fish-boat holds
25 Hide storage cellars
23 Fresh-frozen ice cream
20 Moth-killing fur storages
15 Brine for ice skating rinks
10 Freezing Shell-Ice
5 Ice cream cabinets
0 Frozen-food display cases
– 5 Long-term butter storage
– 10 Frozen pork and beef stg.
– 15 Optimum frozen-food stg.
– 20 Commercial quick-freezers
– 22 Refrig.-12 at atmos. press.
– 28 Ammonia at atmos. press.
– 30 Hardening ice cream
– 40 Storage of aluminum rivets
– 44 Propane liquefies
– 50 Quick-freezing tunnels
– 54 Propylene liquefies
– 90 Testing rockets & fuels
– 100 Research laboratories
– 109 Dry ice temperature
– 128 Ethane liquefies
– 140 Hardening cast aluminum
– 155 Ethylene liquefies
– 258 Methane liquefies
– 297 Oxygen liquefies
– 318 Liquid air temperature
– 320 Liquid nitrogen temp.
– 411 Neon liquefies
– 423 Hydrogen liquefies
– 452 Helium liquefies
– 460 Absolute zero

- Frick developed the first successful system for cooling batches of synthetic rubber with direct-expansion ammonia coils. This patented system is now used in the most important new plants from Mexico to Canada.
- Frick has furnished refrigeration and air conditioning to many of the nation's finest laboratories.
- Frick serves the synthetic fertilizer industry by supplying compressors for condensing ammonia and for cooling the storage shells.
- Frick equipment handles loads between minus 150 and plus 100 degrees F., using *any* refrigerant required and using fully automatic controls if desired.
- A Frick engineer will be happy to discuss air conditioning or refrigeration systems for *your* industry at your convenience. No obligation at all.

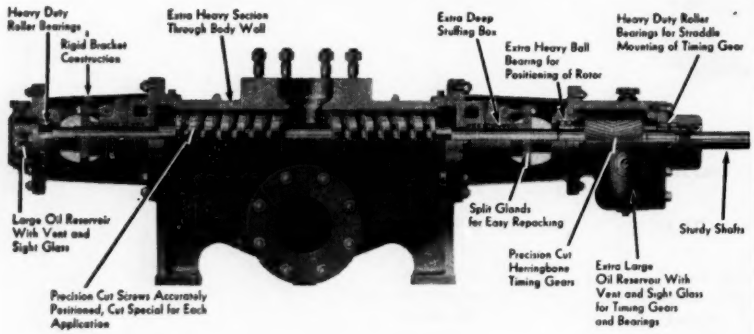
Frick Company • Waynesboro, Pennsylvania

THIS PUMP SPECIALIZES IN "IMPOSSIBLE" CHEMICAL PUMPING PROBLEMS

. . . examine these special features of the

WARREN

EXTERNAL GEAR AND BEARING SCREW PUMP


Heavy Duty Roller Bearings
Rigid Bracket Construction
Extra Heavy Section Through Body Wall
Extra Deep Stuffing Box
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Heavy Duty Roller Bearings for Straddle Mounting of Timing Gear
Large Oil Reservoir With Vent and Sight Glass
Precision Cut Screws Accurately Positioned, Cut Special for Each Application
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Extra Large Oil Reservoir With Vent and Sight Glass for Timing Gears and Bearings
Sturdy Shafts

. . . then see what it can do:

- Pumps highly viscous liquids or semi-liquids most effectively; discharge pressures nearly unlimited for high viscosity liquids; up to 700 psig for low viscosity liquids, with capacities to 3000 GPM and operating temperatures to 700°F.
- Pumps liquids from systems under high vacuum, with special modifications; has handled vacuums down to 10 microns, with no special seals or without submerging the pump. Mechanical seals are not required.
- Pumps many types of slurries, since it does not trap liquids as gear pumps commonly do.
- Pumps with a constantly high volumetric efficiency because of low internal slippage; is excellent for metering large capacities.
- Pumps quietly and smoothly and is ideal for extruding material where a flawless surface is necessary.
- This highly adaptable Warren External Gear and Bearing Screw Pump, available in an almost endless number of patterns, can solve special space or piping problems too. And it can be furnished with heating or cooling jackets, with hopper type body, and in any metal your problem requires.

Now, consult a Warren engineer for help with your "impossible" chemical pumping problem or write for detailed Bulletin 206

WARREN

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WARREN PUMPS, INC.

WARREN, MASSACHUSETTS

C-10

LITERATURE . . .

Jaw Crusher.....employs the "crushing without rubbing" principle. Widely used for crushing a variety of materials in the chemical industries. Described in Bul. 5012.
121b *Pennsylvania Crusher

Lubricators.....The Force Feed Lubricator features dependable, accurate lubrication. Catalog gives complete data on all the lubricators is available.
292 *Manzel

Mixer.....New Model RL Hi-Shear Head Mixer offers finer, faster blending, dispersing and homogenizing. All parts stainless steel. Chemically inert seals. Information
R291 *Gabb Special Products Inc.

Mixers.....A complete line from lightweight portables to heavy duty, fixed mounted, propeller & turbine mixers. Portable mixers are described in Bul. 530.
TL289a *Eastern Industries, Inc.

Mixers.....Illustrated brochure with specifications on all models & sizes of Lancaster Counter-Current Rapid Batch Mixers for uniform precision mixing.
BL301 *Posey Iron Works, Inc.

Mulling.....The 12-page handbook on mulling explains controlled dispersion & gives details on 9 Mix-Muller models (¾ to 60 cu. ft. batch capacity).
157 *National Engineering Co.

Process Engineering.....This subject is covered completely & in great detail in a booklet entitled "Engineering Specialties: A Challenge" which is available.
L293 *Western Supply Co.

Process Equipment....."Sub-A" Flotation is available in sizes from 16" x 16" to 72" x 72". "Cell-to-Cell", "Free-Flow", and Type "M". Bulletin F10-B86.
297f *Denver Equipment Co.

Process Equipment.....Engineering catalog describes all the equipment that is available; jacketed reactors, tanks, steam-jacketed agitating type kettles, etc.
R295 *Groen Mfg. Co.

Process Equipment.....Mikro-Bud offers grinds from granular to the lower micron ranges & capacities up to 20,000 lbs/hr on certain materials. Bulletin 51-C-1.
231 *Mikro-Products

Process Equipment.....The Turbulizer solves many dispersion problems in the chemical & food industries. Features heavy steel shell with machined interior. Information.
107 *The Strong Scott Mfg. Co.

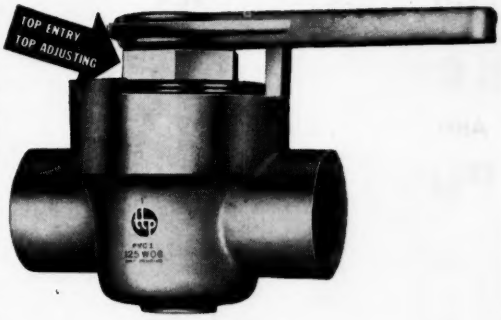
Process Equipment.....Glass-lined equipment for the chemical processing industry. Progressive reactors, Vessels, and Agitators in all shapes & sizes. Product data offered.
10-11 *A. O. Smith Corp.

Process Equipment.....Design & fabrication, including welding of all types of stainless steel, nickel, Hastelloy, Monel, Titanium, T-1 & many other materials. Bul. CN559.
59 *Struthers Wells Corp.

Processing Equipment.....Welded aluminum tanks, pressure vessels and processing equipment for the chemical and processing industries. "Tank Talk" offered.
BL297 *R. D. Cole Mfg. Co.

*From advertisement, this issue

New ball valve for corrosive service ...easier to operate and maintain



Greatly simplified access for maintenance and easy adjustment without dismantling are made possible by a unique top-entry design of a new ball valve announced by Tube Turns Plastics, Inc. These features, combined with the basic operating advantages of the ball valve, provide important economies for corrosive piping services.

- **Easy to operate** ... simple quarter-turn action with self-indicating port position ... positive, instantly responsive flow control ... self-lubricating "Teflon" seat rings prevent seizing.
- **Easy to maintain** ... top-entry permits removal of one-piece ball and stem for on-the-line maintenance.
- **Easy to adjust** sealing force on seats ... by nut on bonnet, without disconnecting valve.

This new **ttp*** ball valve is available in injection molded UPVC (unplasticized polyvinyl chloride) for up to 150°F, and in "Penton" (chlorinated polyether) for service to 225°F ... in socket, threaded or flanged ends. Write for Bulletin TTP 180. TUBE TURNS PLASTICS, INC., Department CE-6, 2929 Magazine Street, Louisville 11, Kentucky.

*"ttp" is a T. M. Reg. U. S. Pat. Off.

NEW SPRAY-ON FLUORESCENT PENETRANT

Finds ALL Cracks, Pores, Leaks IN NONMAGNETIC MATERIALS

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Ready to use. Nothing else to buy. ALL MATERIALS IN PUSH-BUTTON CANS. Includes high-intensity black light.

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Whether your specific need is for more efficient mixing; faster, even cooking temperatures, or quick cooling of cooked material, Groen equipment *does it better.*

Steam-jacketed agitating type kettles heat up faster—save time. Provide more thorough mixing and controlled cooling.

New stainless steel steam-pressure cooker in standard models or special sizes.

Stainless steel jacketed reactors.

Complete line of stainless steel tanks in vertical and horizontal designs.

GROEN ALSO MAKES: Vacuum pans; Coils; Coating pans; Filters; Tubular heat exchangers; Pilot plant processing units; Custom equipment. Write for engineering catalog.

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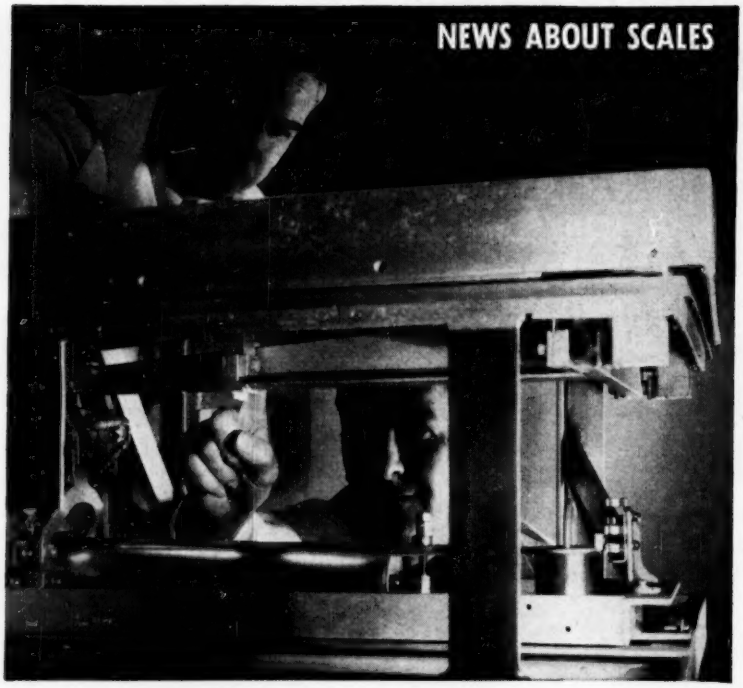
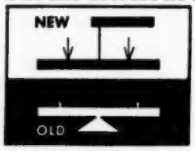


How do they build unvarying accuracy into this remarkable new kind of weighing instrument?

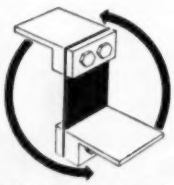
For 7,000 years men have employed the multi-part pivot balance to compare weights. As the parts of their pivot joints wore, the problem of retaining accuracy became more and more acute. Then in 1956 the United States issued a patent for a "Thayer Flexure Plate" Leverage System. A team of engineers and businessmen, aware of industrys great cumulative loss of materials in weighing operations, had devised a revolutionary new scale. Knife-edge pivots that progressively wear and change were replaced by Thayer Flexure Plates that move only .001", yet accurately reflect the minutest changes in weight. This *firmly joined* lever withstands shocks and vibrations indefinitely. Dirt and dust are no longer a problem.



Thayer guarantees this leverage system accurate for the life of the scale.

How Can It Save You Money Year After Year?

Working in conjunction with straight electrical controls, it forms the most reliable, low maintenance system ever devised to control processing or materials handling *by weight*. Literature on its application to filling, batching and checkweighing operations is available on request.



THAYER SCALE

AUTOWEIGHTION SYSTEMS FOR FILLING BATCHING AND CHECKWEIGHING

THAYER SCALE CORP. THAYER PARK PEMBROKE, MASS.

A Subsidiary of SUNDSTRAND CORPORATION

LITERATURE . . .

Processing Equipment.....Votator is used for continuous polymerization reactions in numerous installations. Packaged Votator pilot systems are now available. Details.
142 *Girdler Process Equip. Div.

Purifiers.....Specification Manual 803 contains data on 13 types of purifiers, separators, mist extractors, scrubbers. Available now on request from you.
BL285 *The V. D. Anderson Co.

Reagent Feeders.....Both wet and dry feeders are available. Many standard units in stock. Complete information contained in Bulletin F6-B8.
297e *Denver Equip. Co.

Ribbon Blender.....features all welded construction and approved sanitary design. Quickly demounted for cleaning. All sizes usually in stock. Brochure.
L283 *Falcon Mfg. Div. of First Mach.

Roller Mills.....Specification on the roller mill contained in Bul. 153-A. Details on its use on the Durkee systems contained in Pointers, Vol. 2 No. 5. which is also offered.
312b *Sprout, Waldron & Co., Inc.

Rotary Airlock Feeders.....for dust control and pneumatic conveying. Bulletin P58, "How to Select A Rotary Airlock Feeder" is now available.
BL289 *Prater Pulverizer Co.

Samplers.....Continuous mechanical & automatic types for dry, solution or slurry sampling. Complete sampling plants & sample processing equipment. Bul. S1-B4.
297j *Denver Equipment Co.

Screens.....for efficient wet or dry screening. "True-Circle" eccentric action. Sizes to 6' x 14' in stock. Trommel Screens in sizes from 30" x 60" x 120". Bul. S3-B15.
297k *Denver Equipment Co.

Scrubber.....The UW-4 unit for separation of extremely fine dusts & abrasive materials & is ideally suited for heavy dust loads & high temperature applications. Bul. 7460.
33 *The Ducon Co., Inc.

Scrubber.....Flooded Disc Scrubber is completely adjustable. The flooded disc adjusts for cleaning efficiency over a wide range of operating conditions. Bul. 110.
144 *Research-Cottrell Inc.

Scrubber, Gas.....A copy of the brochure giving complete data on Chemico Venturi gas scrubbers is available. Also technical assistance on a specific problem.
37 *Chemical Construction Corp.

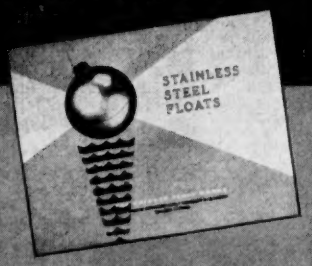
Solids-Processor.....adds vacuum drying to liquid-solids blending. Systems completely packaged. In standardized models with charge capacities from 1 to 50 cu. ft.
72-73 *Patterson Kelly

Spiral Rake Thickeners.....move settled materials to center in one revolution. Acid proof construction available. Further information in Bul. T5-B6.
297l *Denver Equipment Co.

Spray Nozzles.....Catalog 24 contains 48-pages of reference data on thousands of spray nozzle designs and sizes. Choice of capacities, characteristics & materials.
259 *Spraying Systems Co.

* From Advertisement, this issue

EVERY ENGINEER
should have a copy of this new booklet



on STAINLESS STEEL FLOATS

If you have chemical corrosion problems in process equipment, you'll want to have a copy of this authoritative bulletin on Stainless Steel Floats. All the details are here—construction data . . . application information . . . shape specifications . . . weight tables . . . buoyancy formulas . . . and full details on aluminum, monel and nickel floats as well. All the data you need for specifying and ordering. Send for your FREE copy today!

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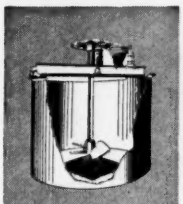
FOR THE CHEMICAL PROCESS INDUSTRY

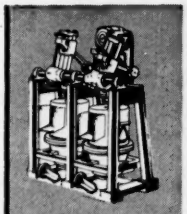


DENVER AGITATORS AND MIXERS

Agitator types available: Turbine-type propeller (to 120" in tanks to 50' dia.), slow speed, high speed, air lift, vertical turbine mixers, mixer-settler units.

Write for Bulletin No. A2-B2

Lab and pilot scale agitators in LG3-B10



DENVER DIAPHRAGM PUMPS

Stroke can be adjusted while pump is operating. Long wearing nylon-reinforced rubber diaphragm. Sizes 1" to 10" simplex and duplex, capacity to 1000 g.p.m.

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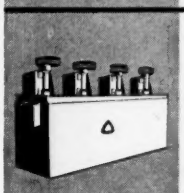
Lab and pilot scale diaphragm pumps in LG3-B10



DENVER ATTRITION SCRUBBERS

High power input to efficiently remove sand coatings, mix dense slurries. Rubber lined or acid-proof tanks. Sizes to 56"x 56".

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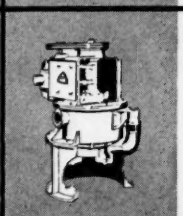
Lab and pilot scale scrubbers in LG3-B10

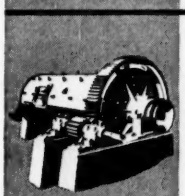


DENVER VERTICAL CENTRIFUGAL PUMPS

For handling frothy liquids or coarse, sandy slurries, constant or intermittent flow. No packing gland or sealing water. Standard or stainless steel construction. Capacity to 450 g.p.m.

Write for Bulletin No. P10-B5

Lab and pilot scale vertical centrifugal pumps in LG3-B10



DENVER BALL AND ROD MILLS

Offer operation and convertibility. Wet or dry grinding systems. All steel construction. Ceramic or rubber linings available. Sizes to 10'x 20'.

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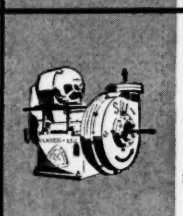
Lab and pilot scale mills in LG3-B10

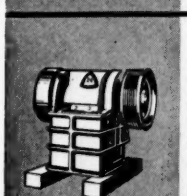


DENVER SRL (RUBBER LINED) PUMPS

High efficiency, low horsepower. Parts last longer, cost less. Rubber lined. PUMPS AND PARTS IN STOCK. Sizes to 5000 g.p.m.

Write for Bulletin No. P9-B10

Lab & pilot scale SRL pumps in LG3-B10

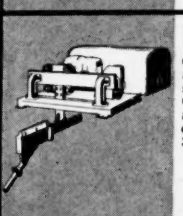


DENVER JAW CRUSHERS

Cast steel frame, anti-friction side bearings and bumper bearings. Manganese steel jaw and cheek plates. Sizes from 2¼"x 3½" to 36"x 48".

Write for Bulletin No. C12-B12

Lab and pilot scale crushers in LG3-B10



DENVER SAMPLERS

Continuous mechanical and automatic types for dry, solution or slurry sampling. Complete sampling plants and sample processing equipment. SAMPLERS IN STOCK.

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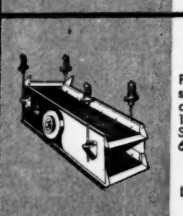
Lab and pilot scale samplers in LG3-B10

DENVER REAGENT FEEDERS

Both wet and dry feeders available. Let us know your requirements. Many standard units in stock.

Write for Bulletin No. F6-B8

Lab and pilot scale feeders in LG3-B10

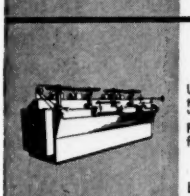


DENVER SCREENS

For efficient wet or dry screening. "True-Circle" eccentric action. Sizes to 6'x 14' in stock. Also Trommel Screens in sizes from 30"x 60"x 120".

Write for Bulletin No. S3-B15

Lab and pilot scale screens in LG3-B10



DENVER "SUB-A" FLOTATION

Universal tank with three types of mechanisms: (a) "Cell-to-Cell"; (b) "Free-Flow"; (c) Type "M". Sizes from 16"x 16" to 72"x 72".

Write for Bulletin No. F10-B86

Lab and pilot scale flotation in LG3-B10

DENVER SPIRAL RAKE THICKENERS

Move settled materials to center in one revolution. Simple, efficient, heavy-duty gear mechanism for thickeners to 150' dia. Acid proof construction available.

Write for Bulletin No. T5-B6

Lab & pilot scale thickeners in LG3-B10

DENVER
EQUIPMENT COMPANY

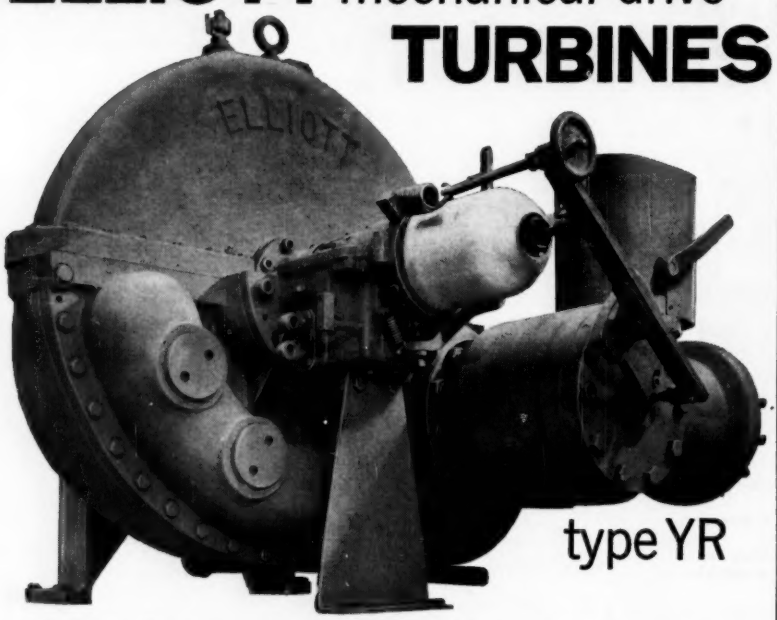
Box 5268, Denver 17, Colorado
Phone CHerry 4-4466

SEE OUR CATALOG ON PAGES 997-1004 IN CEC.

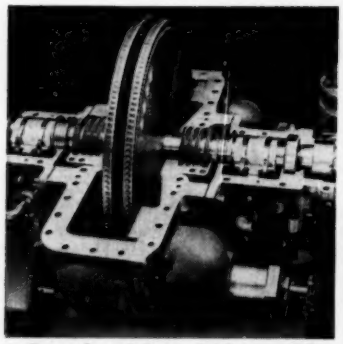
DENVER TESTING FACILITIES

You will have problems in crushing, grinding, settling and possibly concentration and filtering. These are our specialties so please let us help you in our Test Department. Deco flowsheets are reliable and proven.

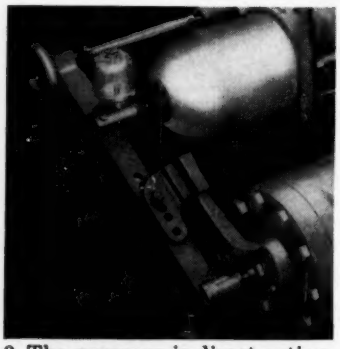
ELLIOTT mechanical drive TURBINES



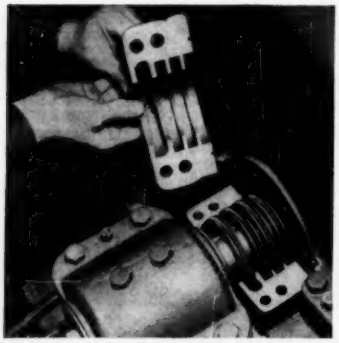
These features mean long life, easy operation



1. Smooth and dependable operation at all operating temperatures is assured by the precise alignment of the dynamically balanced shaft.



2. The governor is direct-acting, simple and weather-proof. Separate trip gives over-speed protection. Easily reset against line pressure.



3. Accessible shaft-seals and bearings simplify maintenance and inspection. Covers are readily removable without disturbing the casing.

4. Economy at partial loads is secured by the steam-saving hand valve with pilot, which can be opened against full steam pressure.

ELLIOTT Company
JEANNETTE, PENNA.

HO-2

LITERATURE . . .

Tornado Mill.....New Size 1 is built for increased capacity. It granulates, pulverizes, disperses, & recovers scraps. Can be taken apart & cleaned thoroughly. Facts.
310 *F. J. Stokes Corp.

Tube Mills.....for wet or dry grinding. Available from 2 to 10 feet in diameter; 6 to 35 feet in length; single or multiple compartments. Specifications & Bulletin 18-B-11.
284 *Hardinge Co., Inc.

Pumps, Fans, Compressors

Fans.....Details on how De Bothezat Bifurcator Fans can improve ventilating efficiency. Protective housing shields motor from contact with hot or corrosive fumes.
247 *American Machine & Metals, Inc.

Compressor.....The Model CRX produces pure, oil-free air without special filters. Sizes range from 100 to 1400 cfm. Keeps air-actuated equipment moving.
46 *Gardner-Denver Co.

Compressors.....Complete information on how Cooper-Bessemer can help you plan compression & power facilities. "Copper-Bessemer Equipment for Chemical Plants".
40-41 *Cooper Bessemer

Compressors.....Complete information on Dynamic Compressors in Bul. 922-11. Available in sizes from 15 to 1500 hp for handling air or gases.
103 *Joy Mfg. Co.

Compressors.....Oil-Free Compressors feature chrome-plated cylinder walls. Complete details on how to get truly low cost, oil-free air contained in Bul. 926.11.
101 *Joy Mfg. Co.

Pump.....Available in all metals and alloys in a complete range from 1½" to 16". Features large diameter shafts & heavy duty bearings. Bul. 203-8.
R303 *Lawrence Pumps Inc.

Pump.....“Karbate” impervious graphite pumps offer corrosion resistance and are readily available from stock in a wide variety of models & sizes. Literature.
151 *National Carbon Co.

Pump.....“Karbate” type F Motor-Mounted pumps with redesigned seal arrangement improves overall operation. Additional data contained in Catalog Section S-7253 CJ.
223 *National Carbon Co.

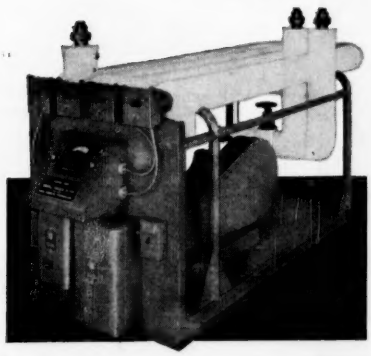
Pumps.....Complete information on capacities, pressures and sizes contained in reprint (Data Sheet 100). Answers to your pumping problems, etc.
56 *Aldrich Pump Co.

Pumps.....SRL (Rubber Lined) pumps offer high efficiency, low horsepower. Sizes to 5000 g.p.m. Additional information in Bul. P9-B10.
2971 *Denver Equipment Co.

Pumps.....Anniversary Booklet traces the development of the pump from its earliest beginnings, & also includes a summary of recent developments in pumping equip.
137 *Ingersoll-Rand

* From advertisement, this issue.

HI-TEMPERATURE LO-PRESSURE



liquid phase heat transfer systems

if
—Your product temperature requirements are high
—You want to avoid high pressure equipment
—You need close temperature control and safe, automatic operation at reasonable cost . . .

. . . . You should consider a space saving, all electric, Merrill Process System

Write for Bulletin 597 giving details of the Pilot Plant Series or send us your requirements.

MERRILL PROCESS SYSTEMS

Parks-Cramer Company
FITCHBURG 13, MASS.

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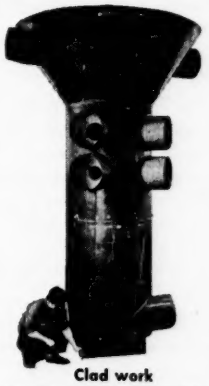
SPECIALIZED WELDED HEAT AND CORROSION RESISTANT **FABRICATIONS**

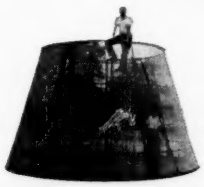
ROLOCK can expedite solution of **special process equipment** problems

Rolock combines *specialized* welded-fabrication and machining skills with an experienced and fully staffed engineering department for assistance in design, as well as production and test supervision.

Rolock people are experts in work with high temperature and corrosion-resistant alloys, including Inconel, Incoloy, the Hastelloys, Monel and Stainless Steels. The Rolock plant, capable of handling fabrications of large size and scope, is equipped with manual and automatic welding equipment of advanced type, with personnel qualified for standard, special or specified code welding requirements. We are also equipped to inspect and test to customers' specifications. Write outlining your needs.



Clad work



A large alloy mesh fabrication

Alloy special duct work

A heavy alloy baffle

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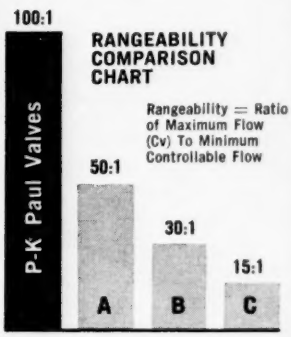
General Kinetics Corp.

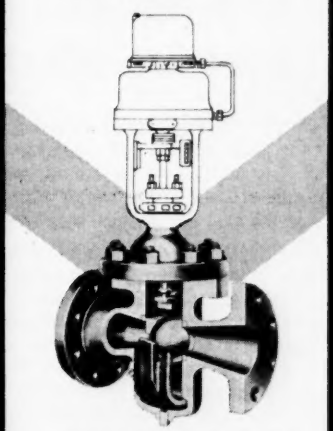
P-K PAUL CONTROL VALVES OFFER

PRECISION CONTROL

OF LESS THAN 1% OF MAXIMUM FLOW



A—Globe Valves, V-Port Plug
B—Globe Valves, Contoured Plug
C—Butterfly Valves



- **Higher Flow Capacity**
- **Positive Shut-Off**
- **Non-Turbulent Flow**
- **Low Operating Thrust**
- **Self-Purging**
- **Resistant to Erosion and Abrasion**

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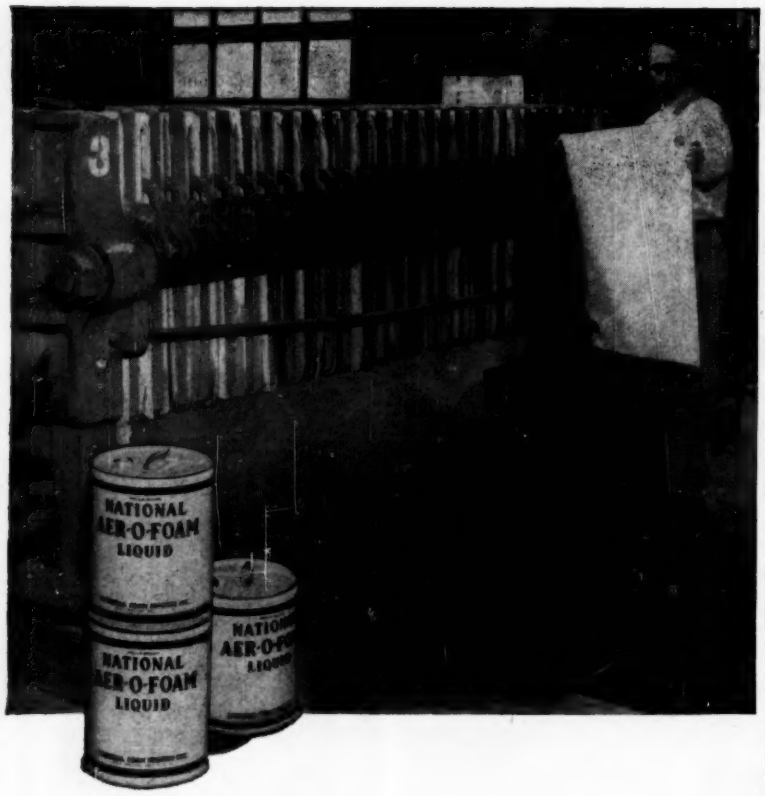
197 SOUTH VAN BRUNT STREET
General Kinetics Corp.
ENGLEWOOD, NEW JERSEY



Eaton-Dikeman filter papers help National Foam System fight fire effectively

"Fire fighting foam liquids must be free from all suspended solids to insure chemical stability and satisfactory performance in the equipment in which they are used. We believe our Aer-O-Foam fire fighting foam liquids are the *cleanest* in the world," says D. N. Meldrum, Chemical Director, National Foam System, Inc., West Chester, Pa.

At National Foam, natural protein is hydrolyzed in an alkaline medium and further treated to extract foam stabilizing fractions from the protein. The digested material is filtered through Eaton-Dikeman filter paper grade 953 laid over cloth on a 36" Sperry press to remove undesirable fractions and solid residual material. The use of E-D filter paper with the cloth filter gives National Foam two advantages: (1) a much higher degree of filtration than would be possible with cloth alone, and (2) production costs are cut because the filter cake is built up on the inexpensive filter paper, allowing the more expensive filter cloth to be re-used.

Filtering protein extracts in manufacturing fire fighting foam liquids may not be your particular problem, but whatever you filter, chances are you can do it better, faster and at less expense with one of Eaton-Dikeman's many grades. Why not talk it over with an E-D filtration expert. He will be happy to help you find the right paper for your particular requirement. In the meantime, send for a FREE sample folder of quality E-D papers today.

E D ®

THE EATON-DIKEMAN COMPANY

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MOUNT HOLLY SPRINGS, PENNSYLVANIA

"First with Filter Paper exclusively."

LITERATURE . . .

Pumps.....Moyno pumps handle chemicals that ruin other pumps. Bulletin 40 CE contains complete information on how to reduce pumping costs.
131 *Robbins & Myers, Inc.

Pumps.....Bulletin V-837 covers vertical pumps for pumping molten chemicals and horizontal pumps for handling black liquor, caustic, etc., in evaporator service.
L278 *Taber Pump Co.

Pumps.....For your pumping or installation problems valuable information is containted in catalog series CC and series SP-507. Available on request.
R285 *Viking Pump Co.

Pumps, Acid.....in a variety of metal alloys, as well as plastic, to cover a wide range of corrosive applications. 1" to 8" discharge sizes with 10 to 3000 GPM.
315 *A. R. Wilfley & Sons, Inc.

Pump, Centrifugal.....Centri-Chem was designed to meet the standardization programs of major, multiplant chemical companies. Capacities to 40 gpm. Lit.
119b *Eco Engineering Co.

Pump, Centrifugal.....in PVC and Polypropylene are available in a broad range of sizes and have capacities of 10 through 180 GPM. Specifications information.
252 *Vanton Pump & Equipment Corp.

Pump, Diaphragm.....Stroke can be adjusted while pump is operating. Sizes 1" to 10" simplex and duplex, capacity to 1000 g.p.m. Bulletin P8-B12 offered.
297g *Denver Equipment Co.

Pump, Diaphragm.....for those hard-to-handle fluids; corrosive, abrasive, viscous, thick, heavy, quick setting, etc. Bulletin 148 is offered.
R283 *T. Shriver & Co., Inc.

Pump, Gear.....Improved design . . . now 12 gpm. All wetted parts acid-resistant, wear-resistant Ace hard rubber. Complete information in Bul. CE-55.
266a *American Hard Rubber Co.

Pump, Gear.....Gearchem for temperatures up to 400 F. and viscosities to 10,000 SSU. Capacities to 10 gpm. Pressures to 100 psi. Literature.
119c *Eco Engineering Co.

Pump, Industrial.....Positive displacement pump feature twin-balanced impellers, helical timing gears, etc. Maximum capacity 100 GPM. Catalog P302.
270 *Waukesha Foundry Co.

Pump, Metering.....A copy of new Catalog 59 is offered. Contains 28 up-to-the-minute pages of metering pump data and methods. Covers the complete line.
149 *Lapp Insulator Co., Inc.

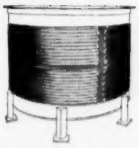
Pump, Rotary.....The All-Chem Rotary displacement pump with twin opposed oscillatfng impellers is designed for severe corrosive service. Capacities to 10 gpm. Lit.
119a *Eco Engineering Co.

Pump, Screw.....External Gear and Bearing Screw Pump can be furnished with heating or cooling jackets, with hopper type body, & in any metal. Detailed Bul. 206.
294 *Warren Pumps, Inc.

* From Advertisement, this issue

NO PIPE COILS

DEAN® PANELCOIL
FOR HEATING—COOLING



Get faster, more uniform, more efficient heating or cooling with DEAN PANELCOIL. Easier installation. Takes less room. Weighs less. Longer service life even under corrosive conditions. Straight or curved Panelcoil sections available to fit any surface.

Dean Panelcoil formed by welding two sheets of metal together, with one or both sheets embossed, to form leakproof integral flow channels for steam, refrigerant, etc.

Latest Data Sheet 15-60 Series and prices sent on request.

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POSEY WORKS FOR BETTER-

PRECISION MIXING

Lancaster Counter-Current Rapid Batch Mixers provide balanced mixing and mulling action for uniform precision mixing of any pre-sized solids with or without liquid additives.

Write for FREE illustrated brochure with specifications on all models and sizes.

POSEY IRON WORKS INC.

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DIVISIONS:
• Iroquois Asphalt Plants • Mixers and Blenders
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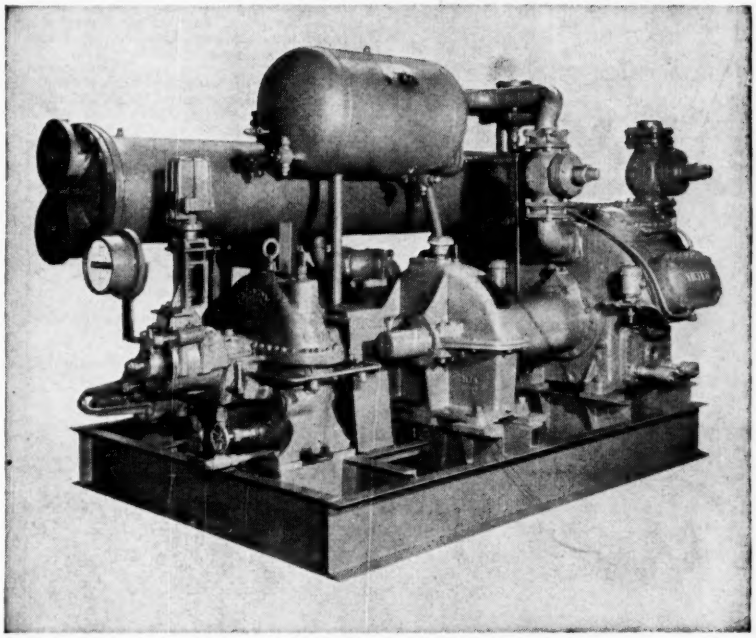
• Large OD Steel pipe

557 S. PRINCE STREET LANCASTER, PA.

Variable refrigeration capacity controls vital chemical reactions



This special Vilter Uni-Chiller has a capacity of 80 tons of refrigeration, operates at 30 degrees suction and 105 degrees condensing temperatures.

Variable refrigeration capacity is of extreme importance in the manufacture of the product of a large southern chemical plant. Vital chemical reactions require holding temperatures within very close tolerances.

However, because the quantity manufactured changes from time to time, great flexibility is demanded of the refrigeration equipment to constantly maintain the proper temperature. This is achieved through a Vilter variable capacity refrigeration system.

Providing this refrigeration flexibility is a special custom-designed Vilter Uni-Chiller which includes: a shell and tube condenser, an eight cylinder compressor, a variable speed turbine operating through reducing gears, explosion proof controls, and special safety components. Varying the turbine speed changes the amount of refrigeration capacity . . . the response is quick.

During manufacturing, the refrigeration circuits are factory assembled and tested, simplifying field installation.

If you have a refrigeration or pressure vessel application, write Vilter for a review of your problem.

Vilter® refrigeration air conditioning

The Vilter Manufacturing Company
Milwaukee 7, Wisconsin

Air Units • Ammonia and Freon Compressors • Booster Compressors Baudelot Coolers • Water and Brine Coolers • Blast Freezers Evaporative and Shell and Tube Condensers • Pipe Coils Valves and Fittings • Pakice and Polarflake Ice machines.

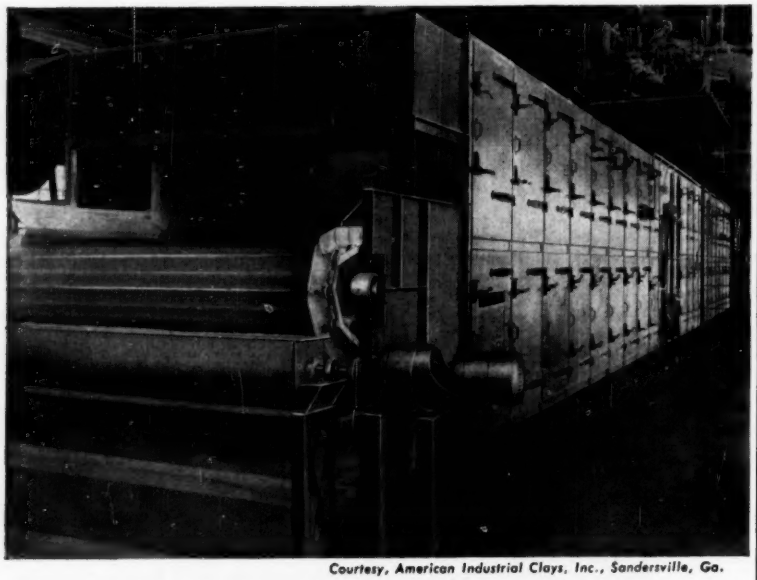
Write for Bulletin 631 to The Vilter Manufacturing Company, Dept. K-903 2217 South First Street Milwaukee 7, Wisconsin

FOR ALL INDUSTRY
WHEREVER THERE'S A
DRYING PROCESS

DRYERS
by
SARGENT

Does your product need short or long exposure drying? Is production measured in ounces or tons? Should it be batch or continuous process drying?
Whatever your needs, there's a SARGENT to do the job. SARGENT Dryers are working in widely varied industries — chemicals, rubber, food, tobacco, textiles — wherever there's a drying process. They are pre-dominant, industry-wide, in profitable operation. Each dryer has these "plus" advantages, standard in every SARGENT machine:

- Exclusive, pre-assembly method means record-breaking speed of installation at your plant.
- Heat source can be gas, oil, steam, electricity.
- Economical — use as little as 1.2 lbs. steam per pound of water removed.
- Drying uniformity; trouble-free operation.
- Rugged construction; takes the gaff of heavy volume production.
- Complete, hold-to-the-line, temperature and humidity controls.
- Dependable, high-level production at unprecedented economy.



Courtesy, American Industrial Clays, Inc., Sandersville, Ga.

SARGENT 2-Stage, Kaolin Dryer With Extruder

To meet required hourly production in design of this dryer, local conditions suggested the economy of using both gas and oil for the heat source. Combination type burners using both fuels on the same equipment, were therefore incorporated in its design for installation on top of the dryer housing with platforms for inspection and maintenance.

This SARGENT 22-section, 2-stage dryer delivers large tonnage hourly of filler or coating clays. Entering moisture is usually 35% wet basis; and leaves the dryer at 2% or less moisture content, as required. The unique SARGENT double hopper extruder feeds the dryer with a very even porous bed of clay on the dryer conveyor. Simple adjustments easily adapt this machine to various densities of clay.

Another example of SARGENT modern design and advanced engineering in building dryers to meet varying requirements.

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Graniteville, SINCE 1852 Massachusetts

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LITERATURE . . .

Pump, Vertical Centrifugal.....for handling frothy liquids or coarse, sandy slurries, constant or intermittent flow. Capacity to 450 gpm. Bulletin P10-B5.
297h *Denver Equipment Co.

Pump, Vertical Turbine.....Bul. 200 describes applications of these pumps for water wells serving municipalities, industry & agriculture, etc.
51c *Layne & Bowler, Inc.

Services & Miscellaneous

Corrosion-Proof Installations.....are covered in Bul. CC-3. Includes; pickling, plating, chemical processing & storage tanks of all kinds, industrial floors, etc.
R278 *Atlas Mineral Products

Fluorescent Penetrant Test Kit.....The new Zyglo test kit finds cracks, pores, leaks quickly. Bulletin outlines the kit & replacement materials.
BL295 *Magnaflux Corporation

Gravel Wall Well.....Bul. 900 gives a complete explanation of gravel wall well construction & accompanying shutter screen use. Also complete specification data.
51b *Layne & Bowler, Inc.

Lubrication.....equipment includes electric, air or hand-operated equipment . . . everything required for high-pressure lubrication, filling of hydraulic systems, etc. Cat.
55 *Stewart-Warner, Alemite Div.

Respirator.....AO R-5055 type for workers exposed to low concentrations of all dusts not significantly more toxic than Lead, Mists & Organic Vapors simultaneously.
128a *American Optical Co.

Respirator-Goggle Combinations..... protect both eyes and respiratory passages against All Dusts, Mists, Fumes and Organic Vapors. Heavy duty lens won't fog.
128b *American Optical Co.

Teflon Lab Ware.....Expanded line includes stirring rods, watch glasses, beakers, evaporating dishes, tubing, all-purpose Teflon tape, etc. New Catalog & Price List offered.
258 *W. S. Shamban & Co.

Test Cabinets.....Literature on the new Type 411 Industrial Test Cabinets is offered. Conformity to most federal & commercial requirements, specifications & procedures.
64 *Industrial Filter & Pump Mfg. Co.

Warehouse Service.....for tantalum, tungsten, molybdenum, columbium, acidproof tantalum chem. equip. Handy guide includes new price and stock list.
8-9 *Fansteel Metallurgical Corp.

Waste Burner System.....Because of its unique design, wastes can be fed directly into the burner eliminating the need for bulky, expensive incinerators. Information.
256 *Thermal Research & Engineering

Well Water Systems.....Bul. 100 gives general facts & information on systems, pumps, drilling & allied services & equipment. Also special water well drilling, service work.
51a *Layne & Bowler, Inc.

* From Advertisement, this issue

INFRARED RADIATION

Just Published. Explains exactly what infrared radiation is and what it does. Analyzes a typical infrared system and discusses the components of such a system, the laws of physics by which it operates, and the materials involved. Clearly describes the limitations, the problems encountered, and the scope and future possibilities of infrared applications. **By Henry L. Hackforth, North American Aviation, Inc. 280 pp., illus., $10.00**

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INDUSTRIAL THERMAL INSULATION

Shows how to select, specify, and apply the most efficient and economical insulation for any industrial need. Gives a wealth of tested methods and data for effectively using modern insulating materials for high and low temperatures. Clearly shows how to apply, fasten, and finish insulation materials on various types of surfaces. **By A. C. Wilson, Owens-Corning Fiberglas Corporation. 295 pp., 114 illus., $9.00**

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Just Published—Second Edition. Provides practical data for solving problems in automatic control device design and for achieving efficient, smoothly operating systems. Presents operating features; outlines systematic design procedures; develops theory through transient-response analysis methods; and uses classical methods to solve differential equations. **By Henry Lauer, Robert Lesnick, and Leslie E. Matson, Eng. Dept., RCA Victor Div. 2nd Ed., 277 pp., 165 figures, $10.00**

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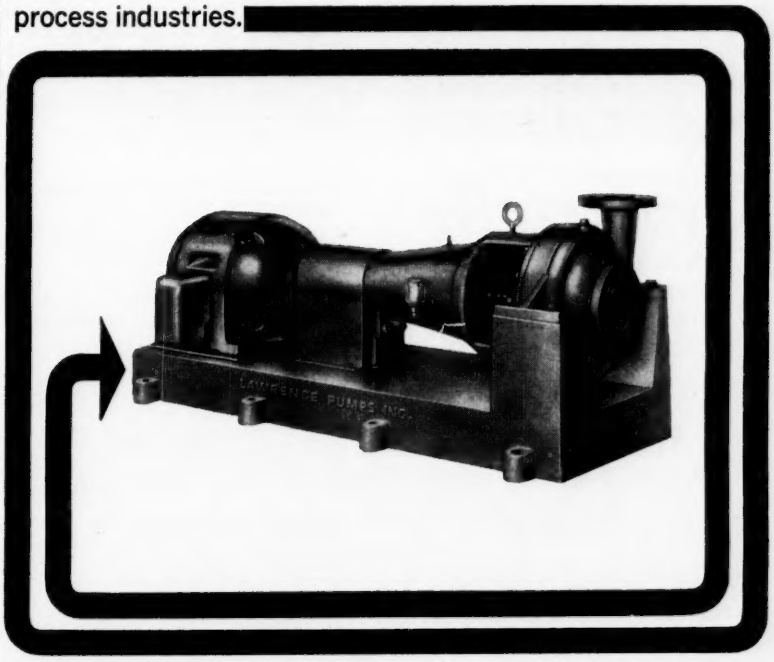
If it's pumpable . . . this process pump can handle it! Here — for the chemical and process industries — is a truly notable achievement in pump design . . . a process pump capable of handling any pumpable fluid — corrosive, hot (1000°F) or cold (—350°F).

This pump can handle anything pumpable because it has virtually everything in the way of features to solve even the toughest pumping problems encountered in the chemical and process industries.



Spacer coupling — to permit removal of impeller, shaft and bearings without disturbing either motor or piping.

Centerline support — to prevent misalignment in handling high temperature liquids.

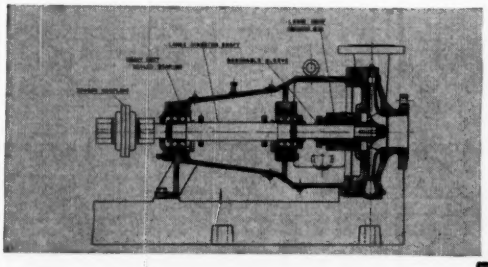
High efficiency enclosed impeller

Extra deep packing box, renewable sleeve — usable either with packing or mechanical seals.

Large diameter shafts, heavy duty bearings — for longer, trouble-free life.

Available in all metals and alloys — carefully chosen to provide best performance for material to be pumped.

In a complete range, from 1½" to 16"



Send for Bulletin 203-8 for the complete story of Lawrence chemical and process pumps

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Concentrating Table: Deister #14, 5' x 8'.
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Dryer: American atmospheric 24 x 48"
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Mixers: Dbl. and sgl. arms sigma blade.
Dry Powder, various sizes.
W. & P. size 14, 50 gal. jkt'd.
Mix-Muller: Simpson Porto 39" st. steel.
Pumps: Rotary, gear, centrif. vacuum.
Screen: Rotex model 41 st. steel.
Still: Double effect st. st. 11.83 gal.
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One Model 2 BH-40 Class D or one Model 4 BH-60 Class D KADY MILL. Top or bottom entering.

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STAINLESS STEEL TANKS

Model J-1 24" x 45" 77 gal. 18,000 cu. in. 400 PSI 10 gauge type 304. Ship. wt. 250 lbs. Net 150. Value $300 BRAND NEW $99.50
Model F-1 same as J-1 except 8½" x 18". 16 gauge 1000 cu. in. . $14.50. Carton of 8. . $14.25
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ILLINOIS MFG. & SUPPLY CO.
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Classified Advertising Division
Chemical Engineering
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2—6' x 35' Rotary Flame Dryers. ½" shell. Comp/equipped
1—66" x 36' Rot. Monel Lined Flame Dryer. With Firebox
1—6" x 12" Lab 2 Roll Rubber Mill. 5 HP Mtr & Drive
2—French type S-2 Expellors. 30 HP. w/tempering bins
1—Day Cincinnatus 100 gal. work cap Sigma Blade Mixer. Size 6
3—Eimco 8' x 12' Rot. Cont. Vacuum Filters. Closed steel drums
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3—New 25 Ton, 2 GE I Whitcomb.
3—23 Ton, 2-45 Ton Used Gen. Elec.
1—44 Ton, 1-80 Ton Used Gen. Elec.
3—100 & 115 Ton, Gen. Motors, Used
1—25 Ton, Industrial 60' Boom Loco. Crane.

PLANT EQUIPMENT

4' Telsmith Ty Gyratory Crusher.
2—Wemco 2M-HMS-Plants.
36 x 42 Jeffrey Hammermill, Type B-2.
No. 5060 Dixie Mogul Hammermill 500 H. P.
2—6' x 36' Hardinge Ball Mills.
2—5' x 8' Kennedy Van-Saun air swept Ball Tube Mills with Motors & Elec. Eye.
7' x 24' Allis-Chalmers Tube Mill.
5' x 10' & 7' x 15' Rod Mills.
14" x 28" & 30" x 36" Traylor Type H Jaw Crushers.
48" x 72" Buchanan Type "C" Jaw Crusher.
56" x 72" Traylor Style G Jaw Crusher.
No. 1 Sturtevant Rotary Fine Reduction.
2' Symons Standard Cone Crusher.
207-10 Type 316 SS LB Roto Louver Dryer.
36" x 20' Ruggles Coles Class XF-1 Rotary Dryer.
#207-10 & #705—24 Link Belt Roto Louver Dryers.
Link-Belt Mono-Tube 24-10 Dryers.
54" x 35' Louisville Monel Steam Tube Dryer.
72" x 28' Madison Rotary Dryer.
5' x 30' Ruggles Coles Class XA-8 Rotary Dryer.
8' x 60' Rotary Dryer. ½" Welded Shell in Calif.
3' x 30' & 9' x 160' Vulcan Rotary Kilns.
42" x 18" Traylor Type AA Crushing Rolls.
5'-6" x 60' Rotary Dryer or Cooler.
F55 Syntron Grizley Feeder.
24" x 95' NEW Hewitt Robins Truss Belt Conveyor.

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Tel. MU 2-3075

CIRCLE D ON READER SERVICE CARD

JUNE SPECIALS

3 Bird Filters, 18" x 28", 4' x 1' & 24"
Colton #5½ Preformer, max. size 3" x 2½" tablet
Gruendler "BB" Hammermill, Whirlbeater
2 Oliver Rotary Vac. Filters, 3' x 2', 63" x 8'
Pfaudler 1500 gal. glass closed top Tank
Gen. American 42" x 120" Twin Drum Dryer
Rotex Sifter 20" x 48", on high stand, ½ HP mtr.
Abbe 5' x 6' J'ktd. Ball Mill, chrome mang. steel
Ribbon Blenders, Steel & SS, all sizes, New & Used

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YOU CAN BANK ON
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CIRCLE E ON READER SERVICE CARD

IMMEDIATE DELIVERY

Heat Exchangers: 12 units Mgr. Foster Wheeler, 79 to 520 sq. ft. heating surface, type 316 S/S tube & crown sheets. Priced to Sell.

Tanks: 6500 Gal. S/S lined; 3800 S/S lined; 4500 Gal. S/S lined; 1,000 Gal. closed top & bottom.

Mixers: B & P Size 17, 30 HP motor; 17 DAM 80 HP motor; W & P 20 gal. double sigma blade; J. H. Day 75 gal.

Send us your lists of idle equipment

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9370 Byron Street
Schiller Park, Illinois
Gladstone 1-1500

CIRCLE F ON READER SERVICE CARD

CHEMICAL EQUIPMENT DIVISION

Raymond 3 Roll #3036 Hi-Side Mill
Buflovak 19 Shelf Vacuum Shelf Dryers
1000 sq. ft. Stainless Heat Exchangers (2)
Tolhurst 40" S.S. Center Slung Centrif.
Fletcher 40" Susp. Steel Centrifugal
Sweetland #12, #10, #7 Filter Presses
30 Gal. S.S. Jkt'd. Autoclave 1000 PSI Int.
Shriver 30"x30" P&F 36 C.I. Chambers
Nooter 750 gal. Steel Reactor 300 PSI
Traylor 8' x 11' Ball Mill
Beth. Fdry. 7' x 24' Compeb Mills
Link Belt 502-16 Roto-Louvre Dryer
8' x 80' Rotary Dryer 316 S.S.
Mosser 4' x 47' Rotary Dryers
Louisville 6'x50'; 6'x25' Steam Tube Dryer
F. J. Stokes 38A & 382A Tray Dryers
Stainless Tanks 100, 200, 350 gal.
Condensers 100 to 5000 sq. ft. Steel; Admir.
Pressure Vessels 300 to 4500 gal.
Dixie #5060 Mogul Hammermill
Jeffrey Hammermills 36" x 36"; 15" x 8"

HEAT & POWER CO. INC.
60 E. 42nd St., New York 17, N. Y.
310 Thompson Bldg., Tulsa 3, Okla.

CIRCLE G ON READER SERVICE CARD

BALL MILLS—3' x 12' Abbe/40 HP—4' x 6' Allis Chalmers 60 HP Slip Ring/screwfeeder—Kennedy Van Saun 5' x 6' Enclosed gears/50 HP/scales/feeders/exhausters—Hardinge 6' x 12' w/200 HP Slip Ring/drum feeder.

HAMMERMILLS — 20 HP Gruendler X — 30 HP Mikro 3W—40 HP Jeffrey 24 x 20—50 HP Wms. AKBX—100 HP Jeffrey 36 x 42—450 HP Penna SXT 14.

ROTARY DRYERS—24" x 22'—36" x 24'—44" x 25'—5' x 50' (2) all w/motor drives—burners/blowers avail.

VACUUM PUMPS—115 CFM Beach Russ 100 RP w/5 HP motor/Vee belt drive.

SCALES—12500# capacity dial—Fairbanks Printomatic—8' x 6' Platform.

FEEDERS—Syntron FM1,—FM3—w/hoppers/vibrators/controls.

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CIRCLE H ON READER SERVICE CARD

BUY BRILL

CENTRIFUGES

1—Sharples C-27 Super-D-Hydrator, 316 S.S.
1—Bird 18"x28", Solid Bowl, Continuous, 316 S.S.
1—Bird 36"x50", Solid Bowl, Continuous, 347 S.S.
3—Sharples PY14, PN14 Super-D-Canters 316 S.S.
1—Tolhurst 26" susp. Rubber Imperforate Basket.
1—Tolhurst 32" susp. 317 S.S. Perforated Basket.
2—AT&M 48" Suspended 316 S.S. Perforated Basket.
2—Sharples #16, 304 S.S., 3 HP motor.

REACTORS—EVAPS—CONDS—TANKS

1—Alloy 75 gal. 316 S.S. Jktd., Agtd. Reactor.
1—650 gal. 304 S.S. Reactor with 100 sq. ft. Bayonet Heater.
1—1400 gal. Blaw-Knox, steel, jacketed, agitated Reactor.
1—2000 gal. Struthers Wells 316 S.S., Jacketed, agtd., Reactor.
2—3200 gal. 316 & 347 S.S. jacketed, agitated Kettles.
1—4000 gal. 316 S.S. clad agitated Reactor with coils.
1—550 sq. ft. Buflovak monel single effect Evaporator.
1—7500 gal. 316 S.S. Vert. Storage Tank, 7'x25', 50 psi.
1—750 gal. nickel clad Mixing Tank. 125# nickel coils.
6—1200 gal. 304 S.S. Tanks, 6'x6'x6".
1—4000 gal. Haveg Vert. Tank 8'x12'.
3—7500 gal. Rubber Lined Tanks 10'x13'.
1—1500 gal. Stainless Pressure Tank, 5'x10', 90#.
1—12,000 gal. horiz. steel Pressure Tank, 7'6"x36', 200 psi.
6—Stainless Heat Exchangers; 1220, 786, 536, 370, 315, 250 sq. ft.
1—Falls Industries 100 sq. ft. Karbate Condensor.
1—24" dia. x 35', 304 S.S. Bubble Cap Column.

FILTERS

1—Oliver 6' dia. Horizontal Filter, 316 S.S.
1—Oliver 3'x6' Steel Rotary Vacuum Precoat Filter.
1—U.S. 200 sq. ft. 304 S.S. Auto-jet Filter.
1—Industrial 210 sq. ft., 304 S.S. Horizontal Filter.
1—Oliver 5'3"x8' Steel Rotary Vacuum, vaportite housing.
1—Feinc 5'x6' Stainless Steel Rotary Vacuum Filter.
2—#10 Sweetland Filters, 27 leaves, 4" centers, 250 sq. ft.

DRYERS

1—Buflovak Vacuum Shelf with 20—60"x80" shelves.
1—Devine Vacuum Shelf with 19—59"x78" shelves.
1—Devine Vacuum Shelf with 10—40"x43" shelves.
2—Buflovak 42" x 120", atmospheric double drum Dryers, complete.
2—Devine 4'x9', single drum, atmospheric.
1—Buflovak 3'x10' Rotary Vacuum Dryer.
1—Baker Perkins 5'x6"x6' Rotary Vacuum Dryer.
1—Louisville 6'x45', 316 S.S. Rotary Steam Tube Dryer.
2—Louisville Rotary Steam Tube 6'x25', 6'x50'.
2—Louisville 8'x50' Stainless Steel lined Rotary Dryers.
9—Rotary Dryers 34"x30', 4'x40', 6'x50', 6'x60', 7'x80', 8'x87'.
1—Traylor 30"x18' Stainless Steel Rotary Dryer.
2—Link Belt, 7'5"x25', 6'4"x24", S.S. Louvre Dryers.
2—Atmos. Tray Dryers, 16 shelves, 40"x24".
1—P&S 10' wide Apron Conveyor Dryer 48' long.

MIXERS

1—Baker Perkins 100 gal., jacketed, double arm, 30 HP.
1—Baker Perkins #16TRM, 150 gal. jktd., Vac. 60 HP.
1—Baker Perkins 50 gal. jacketed, double arm.
1—Baker Perkins 9 gal. jacketed 304 S.S. double arm.
5—Day "Cincinnatus" double arm, 250 and 100 gal.
2—Steel jacketed Powder Mixers, 225 and 350 cu. ft.
1—Patterson 6' dia. Conical Blender 15 HP.
1—500# Abbe 304 S.S. Powder Mixer.
1—3' dia. Simpson Intensive Mixer.
1—Stokes 21K, 304 S.S. Granulating Mixer 82 gals.

MISCELLANEOUS

2—ISH Mikro Pulverizers, 3 HP.
3—Abbe 2½'x3' porcelain lined Pebble Mill XP motor.
2—Abbe #4 Eureka Jar Mills 21 gals.
1—Raymond 10; dia. Single Whizzer Separator.
1—#5 Mikro Atomizer with motor and cyclone.
2—Bantam Mikro Pulverizers, S.S.
1—No. 1 Ball & Jewell Rotary Cutter.
3—Swenson Walker Continuous Crystallizers, 24" x 30' sections.
2—Robinson Sifters, 40" x 84", Stainless.
1—#24 Rotex Sifter, 20"x64", Quadruple deck.
1—#11 Ro-ball Sifter 20" x 48" 304 S.S.
8—Stokes: DD2, DDS2, T, "R", and "F" Tablet Presses.
4—Nash Vacuum Pumps: H6, TS7, #2.
25—Chlorimet, Durimet and Duriron Centrifugal Pumps, 1½" to 6".

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CIRCLE J ON READER SERVICE CARD

LIQUIDATION

TITANIUM DIOXIDE PLANT
BALTIMORE, MD.

CENT.—FILTERS—EVAPS.—CRYSTAL

1—Bird 32" x 50" Cont. Cent. 316 S.S.
4—Sharples C20 Super D-Hydrators, 316 S.S.
1—AT&M 26" sus. Cent., perf. bskt., 316 S.S.
1—Oliver 8' x 8' Precoat rubber covered Rotory Vacuum Filter.
4—Sperry 36" plate & frame Filters, rubber covered, cast iron, and wood.
5—8' dia. x 24' rubber lined Crystallizers.

PULVERIZERS AND MILLS

2—Abbe 5' x 16' brick lined Mills.
2—30' dia. Stainless Steel Micronizers complete with Hoppers, Conveyors, etc.

ROTARY KILNS

1—Traylor 11' x 155' Rotary Kiln, ⅞" shell.
1—Renn. 6' x 60' Rotary Kiln, ⅝" shell.

RUBBER LINED TANKS

5—8500 gal Vertical Storage 8'6" x 16' x 8' cone.
1—13,000 gal. Horizontal Storage 8' x 35'.

STEEL TANKS

6—2000 to 5200 gal. with Turbo Agitators.
14—Storage Tanks: 3800; 6000; 9000; 10,000; 15,000; 47,000 gals.

MISCELLANEOUS

7—Dorr Thickeners: 16' dia. with Tanks.
1—Bemis 50# Bag Packer with Sewing Machine, Conveyor and Flattener.
50—LaBour, Durco, Worthite, Duriron and Stainless Steel Centrifugal Pumps 2" to 6" with motors.

Representatives on premises,
2701 Broening Highway, Baltimore, Md.
Telephone: Medford 3-2911

BRILL EQUIPMENT CO.
35-65 Jabez Street,
Newark 5, N. J.
Tel: Market 3-7420

CIRCLE K ON READER SERVICE CARD

COMPRESSORS

No better values at any price

74 CFM 1500 PSI 6¼-3¾-1¾x7 CP. TCB3
100 CFM 150 PSI 6x7 Ing. ES-1
104 CFM 2500 PSI 6¾-4¼-11/16x9 IR-ES3
110 CFM 3000 PSI Ing. GC 50BW
138 CFM 100 PSI 7x7, Ing. ES, CP & Joy
151 CFM 3000 PSI 13¾x12 Norwalk TRS-4T
167 CFM Vac. 10x5 Ing. Type 15
288 CFM 100 PSI 9x9 Ing. Worth. CP & Penn
311 CFM 1500 PSI 10½-7⅛-3¼x13 IR-ES3
351 CFM 350 PSI 11-5x11 CP TCB-2
465 CFM 100 PSI 12x11-IR-ES-1-Chic. P.T.
660 CFM 125 PSI 11¼-7x7 Joy Wn 102
686 CFM 100 PSI 14x13 Ing. ES-Chic. P.T.
823 CFM Vac. 18x7 Ing. ES-1
827 CFM 125 PSI 17-10½x14 IR. XRB
1600 CFM (actual) 100 PSI C300-300H Fuller (2)
1721 CFM 110 PSI 23-14x16 Ing. PRE2
2506 CFM 50 PSI 19-19x14 Pennsylvania DE-1

AMERICAN AIR COMPRESSOR CORP.
Chem. Road, North Bergen, N.J. UNion 5-1397

CIRCLE L ON READER SERVICE CARD

BEST BUY

MONEL DRYER

Louisville 54" x 35' long Rotary Monel Steam Tube Dryer. 1120 sq. ft. heating surface. 150# pressure. Code construction. New 1954.

Used only 1 Year

Wire or phone collect—GA 1-1380

ME MACHINERY AND EQUIPMENT CO.
123 Townsend St. - San Francisco 7, Calif.

CIRCLE M ON READER SERVICE CARD

LIQUIDATING

T316 SS CHEMICAL EQUIPMENT
ORANGE, TEXAS

1—Struthers-Wells 3500 gal. T316 SS reactor, jkt. & 40/20 HP Agit., w/int. T316 55 coil
1—Alco 110 sq. ft. T316 SS vert. pressure leaf filter.
2—Vulcan 96" dia. T316 SS bubble cap columns, 37' high
1—Vulcan 72" dia. Copper column, 4' high, VACUUM.
1—17,650 gal. T316 SS horiz. tank, dished heads, coil
3—Worthington 160 ton steam-jet Vac. refrigeration units.
2—Sharples #C-20 Super-D-Hydrators, T316 SS
2—Buffalo type #R, T316 SS blowers, 2330 cfm, 60 HP
2—American type #R T31 SS blowers, 5600 cfm, 50 HP
2—Read 1800 cu. ft. T304 SS weigh hoppers, with T304 SS elevators, shaker conveyors, etc.
1—Struthers Wells 630 sq. ft. T316 SS evaporator.

MANY, MANY OTHER ITEMS
SEND FOR ILLUSTRATED CIRCULAR #1259A

TANK–VESSELS

3—18,000 gal., vert., alum., 12' x 31', cone bottom
1—17,650 gal., horiz., T316 SS, 9' x 36', ¼" shell, ⅜" dished heads, 40# WP.
1—5800 gal., vert., alum., 10' x 10', agit.
10—4500 gal., vert., Nickel-clad, 8' x 11', 125# WP.
1—3700 gal., vert., T304 SS, 6' x 17' VACUUM, int. coils.
1—3300 gal., vert., T304 SS, 6' x 14'6", ⅜" shell, ⅜" heads, 70# WP.
3—2750 gal., vert., T316 SS, 7' x 8', dished heads, 50# WP, 75 sq. ft. coil.
4—2600 gal., vert., T316 SS, 7' x 8', flat bottom, 19# WP, 5 HP agit.
1—2500 gal., vert., T316 SS, 7' x 7', ¼" shell, 5/16" dished heads, 70# WP.
5—2250 gal., vert., T316 SS, 7' x 6'3", dished heads, 70# WP, 5 HP agit.
1—2100 gal., vert., T316 SS, 6' x 9'10" open top, cone bottom.
1—2100 gal., vert., 6' x 10', dished heads, rubber lined.
1—2100 gal., vert., alum., 6' x 10', dished heads.
1—1900 gal., vert., T316 SS, 6' x 8', ⅜" shell & dished heads, VAC. or 100#.
12—1750 gal., vert., hoppers, T304 SS, double cone bottom.
2—1200 gal., vert., T316 SS, 5' x 7', cone bottom, VACUUM.
100—Tanks & vessels, 100 to 1000 gal., all types, etc.

JUST PURCHASED

1—Baker-Perkins #15-UUMM 100 gal. Dispersion mixer, 100 HP, jacket, compression cover, screw tilt, cored blades
2—Buflovak VACUUM Shelf Dryers; 110, 98 sq. ft.
3—National Iron 10' dia. x 78' long rotary dryers, ¾" shell, 4' dia. center tubes. Excellent condition

FILTERS—CENTRIFUGALS

1—Niagara #510-28, 510 sq. ft. vert. leaf, T316 SS, ASME.
1—Alco 110 sq. ft., T316 vert. filter.
1—Niagara #60-30 T304 SS filter.
1—Niagara #53-36 T304 SS filter.
1—Eimco 18" dia. x 24" face T304 SS rotary vacuum.
2—Oliver 5'3" dia. x 3' face rot. vac., pressure precoat, T316 SS, ASME 30# pressure housing.
1—Oliver 5'3" dia. x 8' face, rot. vac., precoat, steel; UNUSED.
8—Sharples #AS-16V super cent. Inconel. Vapor-tite, 3 HP sludge disch.
2—Sharples #16P, T304 SS pressure-tite.
5—Sharples #C-20, C-27 Super-D-Hydrators, T316 SS.
1—Bird 32" x 50" horiz. cent., T316 SS.
2—Sperry 30" P. & F. filter presses, 19-9 st. st. (NI-RESIST).

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1—1450 sq. ft. T316 SS vert. condenser.
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5—400 sq. ft. T316 SS vert. condensers.
50—T316 SS condensers & exchangers: 735, 427, 300, 264, 250, 235, 200, 165, 150, 125, 110, 47, 30 sq. ft.
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9 Devine Vacuum Chamber Shelf Dryers from Lab. Size to No. 36.

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SPROUT-WALDRON 10,000# HORIZ. SPIRAL MIXER

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Lydon elec. heat Dryer 8 trays.
Despatch Ovens Elec. Heated.
Devine Vac. 8 shelf Dryer 38″ x 42″.
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Filters: Vallez 49 S. S. covered leaves.
#2 Sweetland 12 Stainless Leaves.
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Spr. Waldron Stainless spike crusher.
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3 Roll, 9″ x 32″, 12″ x 30″, 16″ x 40″.
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Day Imperial 75 & 150 gals.
Change Can Mixers 8, 15, 40 gals.
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Blystone 3000# horiz. spiral mixer.
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STAINLESS DUST COLLECTOR

Rotoclone type N arrangement C size 16. Stainless contact with 40 HP Fan. Excellent condition.

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CIRCLE U ON READER SERVICE CARD

Look ahead to HIGH PERFORMANCE with GELB PROCESSING EQUIPMENT

1—Pfaudler 200 gal. type 316 SS jacketed reactor with agitator and drive, 75 psi jacket, 20 psi internal.

2—Pfaudler 300 gal. SS jacketed kettles, 76# jacket, 75# internal.

1—Autoclave Engineers SS autoclave, 1 gal. complete with motor, drive and agitator, 1200# working pressure.

2—Blaw-Knox 600 gal. steel jacketed reactors with double motion agitators, 50# jacket pressure, 50# internal.

AUTOCLAVES, KETTLES AND REACTORS

1—Pfaudler Model XL 1000 gal. glass lined jacketed reactor complete with anchor type agitator and drive
2—Pfaudler 200 gal. glass lined jacketed reactors, complete with anchor type agitators and drives
1—Pfaudler 100 gal. glass lined jacketed reactor, complete with anchor type agitator and drive
1—Pfaudler Series P glass lined 30 gal. jacketed kettle, complete with anchor type agitator and drive, 90# jacket, 30# internal
3—Struthers Wells type 316 SS jacketed reactors, 2000 gal., complete with agitators and drives
1—Struthers Wells type 347 SS 400 gal., reactor with coils and turbine type agitator
1—Van Alst 250 gal. S.S. jacketed kettle complete with SS column and condenser
2—Monel 2500 gal. jacketed autoclaves, 175# jacket and 175# internal
1—Blaw Knox 400 gal. steel jacketed autoclave, 570# internal pressure, 85# jacket
1—18,000 gal. type 316 SS pressure tank, 11/ x 24/, 60 psi
1—Patterson Kelley 6000 gal. steel jacketed kettle
1—18,000 gal. aluminum storage tank
5—Aluminum storage tanks, 1300 gal. each

DRYERS

1—Allis Chalmers SS 6' x 50' rotary dryer, complete
10—Allis Chalmers rotary dryers, 6' x 50' and 7' x 60'
3—Link Belt steel roto louvre dryers, Model 207-10, 310-16, 604-20
1—Stokes Model 59DS Steel rotary vacuum dryer, 5' x 30'
2—Louisville rotary dryers, 8' x 50', SS
1—Buflovak SS jacketed rotary vacuum dryer, 3' x 15'
3—Buflovak steel jacketed rotary dryers, 3' x 15', 5' x 20', 5' x 35'
1—Traylor 4' x 40' rotary dryer
1—Rotary dryer 6' x 36'
1—Western Precipitation Corp. SS pilot plant spray dryer, Type N-2
1—Bowen SS pilot plant spray dryer

FILTERS

3—Dorrco rubber covered filters, 6' x 2'
12—Sweetland #12 filters with 72 SS leaves
1—Niagara SS filter, Model 510-28
1—Oliver SS rotary pressure precoat filter, 5'3" x 8'
1—Oliver type 316 SS rotary vacuum filter, 4' x 5'
1—Oliver horizontal filter, 3'
1—GATX SS pilot plant filter, 2' x 6"
10—Shriver plate and frame filter presses, 12" to 42"
1—Shriver aluminum 30" x 30" P&F filter press, 30 chambers

CENTRIFUGES

1—AT&M 48" SS suspended type centrifuge, complete with plow, motor and imperforate basket
1—Fletcher 48" center slung SS centrifuge, complete with perforate basket and motor
4—Tolhurst 40" center slung rubber covered centrifuges, with perforate baskets and motors
2—Fletcher 40# center slung rubber covered centrifuges with perforate baskets and motors

THE GELB GIRL—JUNE 1960

MIXERS

2—Sturtevant #7 dustite rotary batch blenders, New
15—Robinson type 304 SS horizontal blenders, 255 cu. ft.
1—Richmond Engineering type 316 SS 40 cu. ft. horizontal double ribbon blender
1—Baker Perkins Size 20, 2000 gal. double arm jacketed vacuum mixer with double naben blades
1—Entoleter impact mill type PPM-27
1—Stokes SS granulating mixer, Model 21 J
1—Banbury #1 mixer, chrome plate rotor, with 50 HP motor
1—Baker Perkins Size 16, Type UUEM, 150 gal. jacketed double arm dispersion type mixer, complete with compression cover and 100 HP motor
1—Baker Perkins Size 16, Type UUEM, 150 gal. jacketed double arm dispersion type mixer, complete with compression cover and 100 HP motor.

MISCELLANEOUS

1—Vulcan SS bubble cap column, 4' x 25 plates
1—Badger type 316 SS bubble cap column, 42" dia. with 11 trays
1—Badger type 316 SS bubble cap column, 36" dia. with 8 trays
1—Struthers Wells type 316 SS heat exchanger, 330 sq. ft.
1—Condenser Service type 316 SS heat exchanger, 350 sq. ft.
3—Badger type 316 SS heat exchangers, 500 sq. ft. and 600 sq. ft.
10—Davis Engineering SS heat exchangers, 145 sq. ft. New
4—Davis Engineering Carpenter 20, 125 sq. ft. heat exchangers, New
1—Downington type 316 SS heat exchanger, 750 sq. ft.
1—Mikro Model 1SH pulverizer
2—Swenson Type 316 SS vacuum crystallizers, 3'6" x 12', 2' x 12'
3—Williams type 316 SS hammermills, Model AK
1—Sprout Waldron Model 501-D pelleter
1—Ross 6" x 14" 3 roll paint mill, complete
1—Stokes stainless steel coating pan, 3' dia.
50—Steel heat exchangers, 15 sq. ft. to 100 sq. ft.

1—Pfaudler glass lined jacketed reactor Series EL 300 gal. complete with anchor type agitator and drive, 75# jacket, 25# internal.

8—Western States type 316 SS 40" centrifuge with perforate basket, plow and 40 HP motors.

2—Girdler SS heating votators, 10" x 62", jacketed.

2—Girdler SS cooling votators, jacketed, 24" x 6'.

R. GELB & SONS, INC.
U. S. HIGHWAY 22, UNION, N. J. · MURDOCK 6-4900
75 ANNIVERSARY

CIRCLE V ON READER SERVICE CARD

New Stokes size 1 Tornado Mill...

BUILT FOR INCREASED CAPACITY

extra heavy duty • rugged construction • portability

The new Stokes Tornado Mill is specially constructed to meet your requirements for higher capacity. The massive 360° screen covers a full 270 square inches to give a substantial increase in volume . . . and handles even the toughest assignments with capacity to spare.

Notice the heavy duty look of the new Mill. Yet, the new Tornado Mill has the same convenient portability as the popular Size O model . . . and is designed to handle the same types of materials . . . wet, sticky or dry. It granulates, pulverizes, disperses, and recovers scrap. And even with the higher capacity and heavier duty, the new unit can be taken apart and cleaned thoroughly in a matter of seconds.

Why not get all the facts on the new Size 1 Tornado Mill? Just write to Stokes . . . today.

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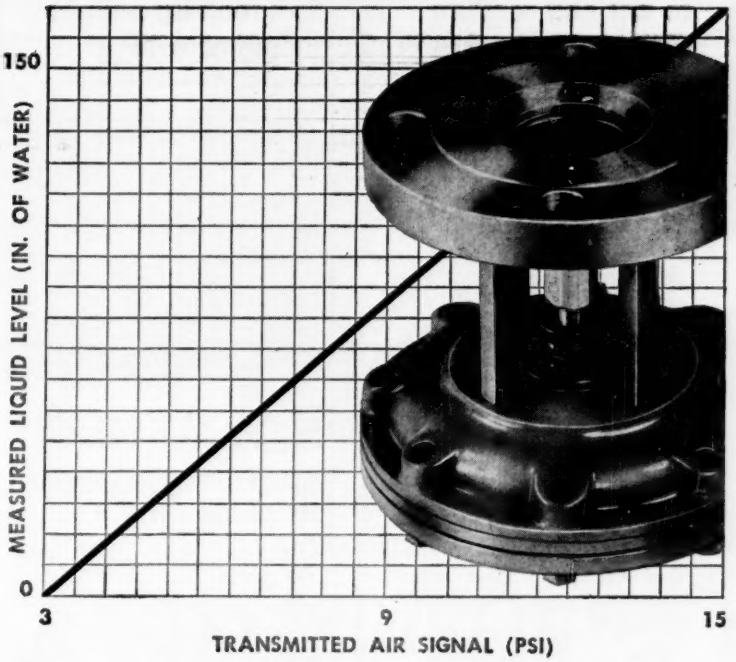
TYPICAL PERFORMANCE CURVE OF MODEL "P" TRANSMITTER



LOW COST PRESSURE AND LIQUID LEVEL TRANSMITTER WITH QUALITY FEATURES FOR DEPENDABLE OPERATION

The Conoflow Model "P" Transmitter is a low cost, rugged instrument which measures pressure and liquid level and transmits a *linear* 3-15 psi signal to standard receiver elements. Incorporates many features not found in more expensive devices for guaranteed dependable operation.

Safety—Process liquids and gases cannot back up into air lines and damage costly instruments. This is assured by the complete separation of measuring diaphragm from pneumatic pilot.

Simple Installation—The Model "P" can be mounted either horizontally or vertically on open or closed vessels. No dip tubes, floats or other mechanical devices are required inside the tank.

Long Life—Only the corrosion-resistant *Inconel X* diaphragm is exposed to the measured material. Preformed diaphragm will not work-harden or fatigue; withstands pressures to 500 psi and temperatures to 450°.

Versatile—Can be used for practically any service; ideal for viscous fluids or materials with solids in suspension; also for flowing bulk materials such as pigments, flakes, etc.

Choice of Ranges—Available for measuring ranges as low as 0 to 100" of water and pressures as high as 250 psi. Ranges can be changed in the field.

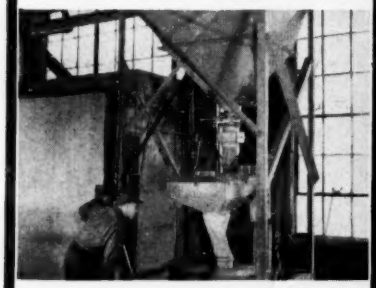
Specifications—New Bulletin P-36-1 contains complete specifications on the Conoflow Model "P" Transmitter. Write for your copy today or ask for a quote. No obligation. Conoflow Corporation, 2100 Arch Street, Philadelphia 3, Pa.

CC-1003

CONOFLOW CORPORATION
FOREMOST IN FINAL CONTROL ELEMENTS
SUBSIDIARY WALWORTH

PROBLEM:

to sift and reclaim PVC resin at rates to 3000 lbs per hour



SOLUTION:

SPROUT-WALDRON GYRO-SHAKER

Valuable resin dust from trimming, scrap grinding and other operations at Columbia Records, Bridgeport, Connecticut, is pneumatically collected at a central location.

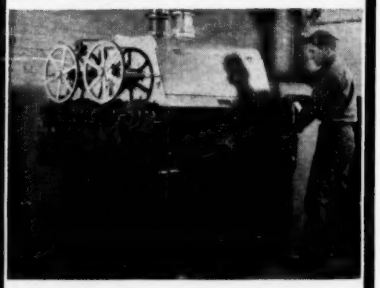
At this point, the job of sifting and reclaiming at rates to 3000 pounds per hour, is turned over to a Sprout-Waldron Gyro-Shaker. The all-metal, dust-tight unit scalps at high capacity, combining speed, reliable operation and efficiency.

At the same plant, another Sprout-Waldron Gyro-Shaker has successfully tackled the problem of sifting the black granules resulting from ground up reject records. Production records show more than 92% acceptable product removed in the first pass.

For additional data on the Sprout-Waldron Gyro-Shaker, ask for Bulletin 160-A.

PROBLEM:

to speed up pepper grinding without losing volatile oils



SOLUTION:

SPROUT-WALDRON ROLLER MILLS

To grind pepper to −40 mesh at production rates from 2-3000 pounds per hour without generating excessive heat or causing unnecessary loss of volatile oils, Durkee Famous Foods, Bethlehem, Penna., installed a Sprout-Waldron pepper grinding system.

Heart of the system is the one-point control double roller mill. Design of this unit permits operator to set and align rolls with complete accuracy in a matter of seconds. The higher the production requirements, the more important is this one-point control feature.

For full details on the Durkee system, ask for Pointers, Vol. 2 No.5. For specifications on the roller mill request Bulletin 153-A.

SW SINCE 1866

SPROUT, WALDRON & CO., INC.

MUNCY, PENNSYLVANIA

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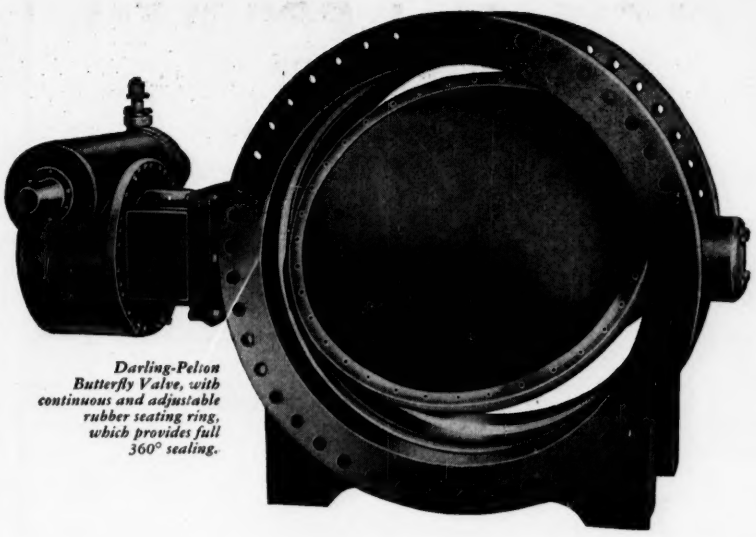

Darling-Pelton Butterfly Valve, with continuous and adjustable rubber seating ring, which provides full 360° sealing.

Surer sealing...easier maintenance

with **DARLING-PELTON BUTTERFLY VALVES**

Darling-Pelton Rubber Seated Butterfly Valves are designed to give bubble-tight shut-off, easy operation and trouble-free service throughout the life of the valve. The sealing member is a continuous resilient ring displaced from the operating shaft... and fully adjustable to give bubble-tight closure around the circumference of the disc.

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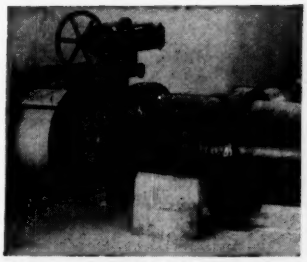
To get *all* the facts, write us for Bulletin No. 5904.

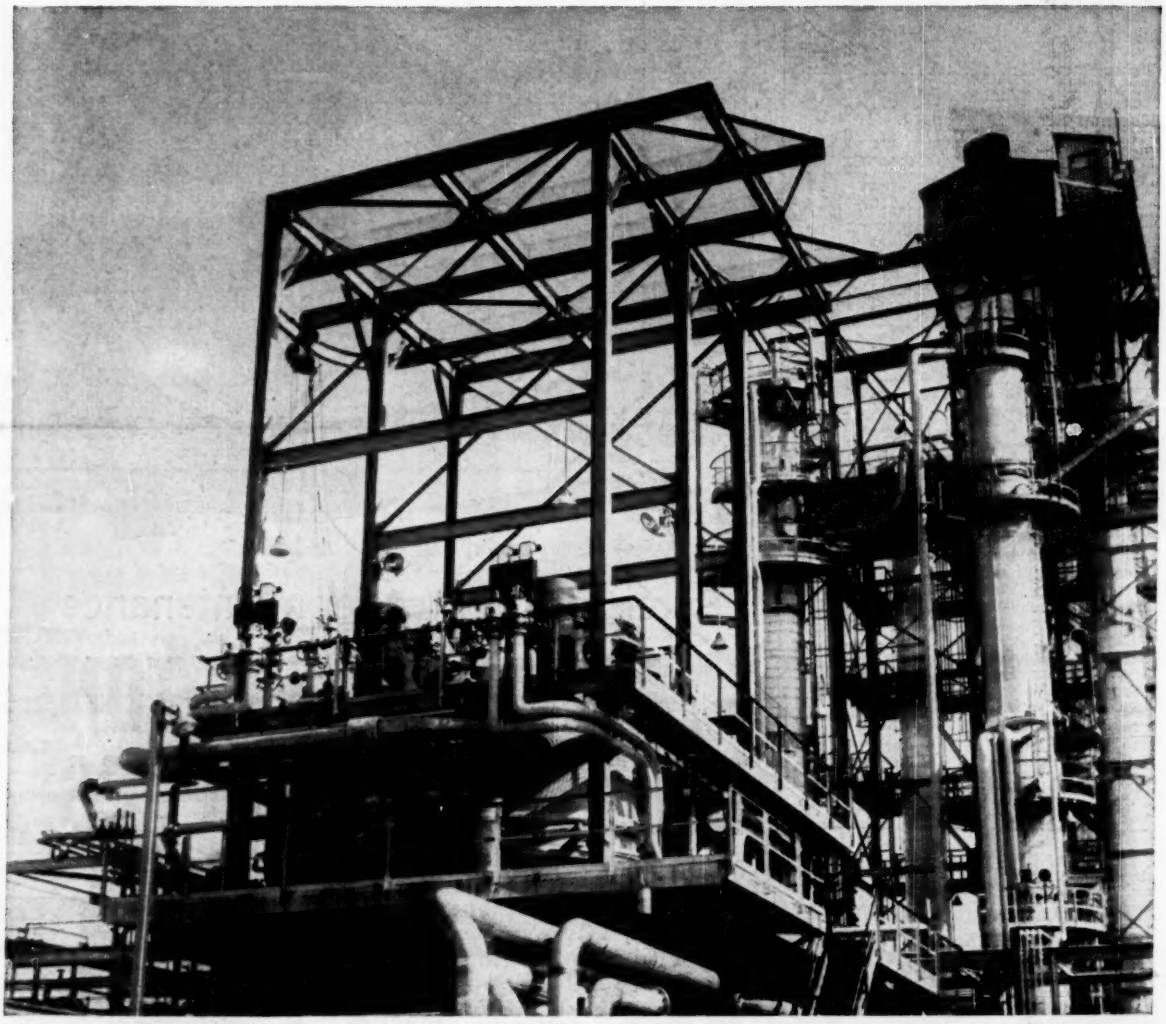


Close-up view of installation in large municipal water plant.

View of Darling-Pelton Butterfly Valves installed in Pittsburgh's new filtration plant.

DARLING VALVES

DARLING VALVE & MANUFACTURING CO.
Williamsport 3, Pa.
Manufactured in Canada by Canada Valve & Hydrant Co., Ltd., Brantford 7, Ontario



CLEANING DOWN-TIME REDUCED 69% WITH ALUMINUM REACTORS by GENERAL AMERICAN

How W. R. Grace urea plant in Memphis, Tennessee cuts cost with four 6,750-gallon General American aluminum reactors.

Before designing these units, General American studied the Turbo-Gas-Absorber in a pilot operation 1/65th the size of the needed capacity. Here they determined the maximum efficiency in absorption, reaction rate and heat transfer within the reactor.

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If you require process equipment, General American engineers will be glad to give technical assistance. You can pre-determine results at our complete East Chicago pilot plant. For complete information, call or write. You'll find *it pays to plan with General American.*

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MAXIMUM PUMPING ECONOMY

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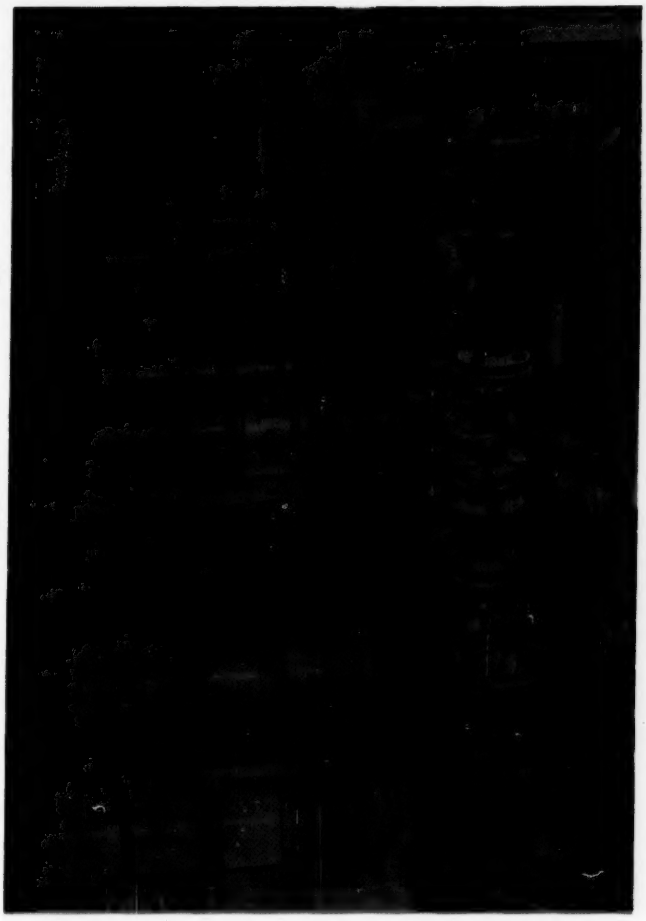


Longer Pump Life

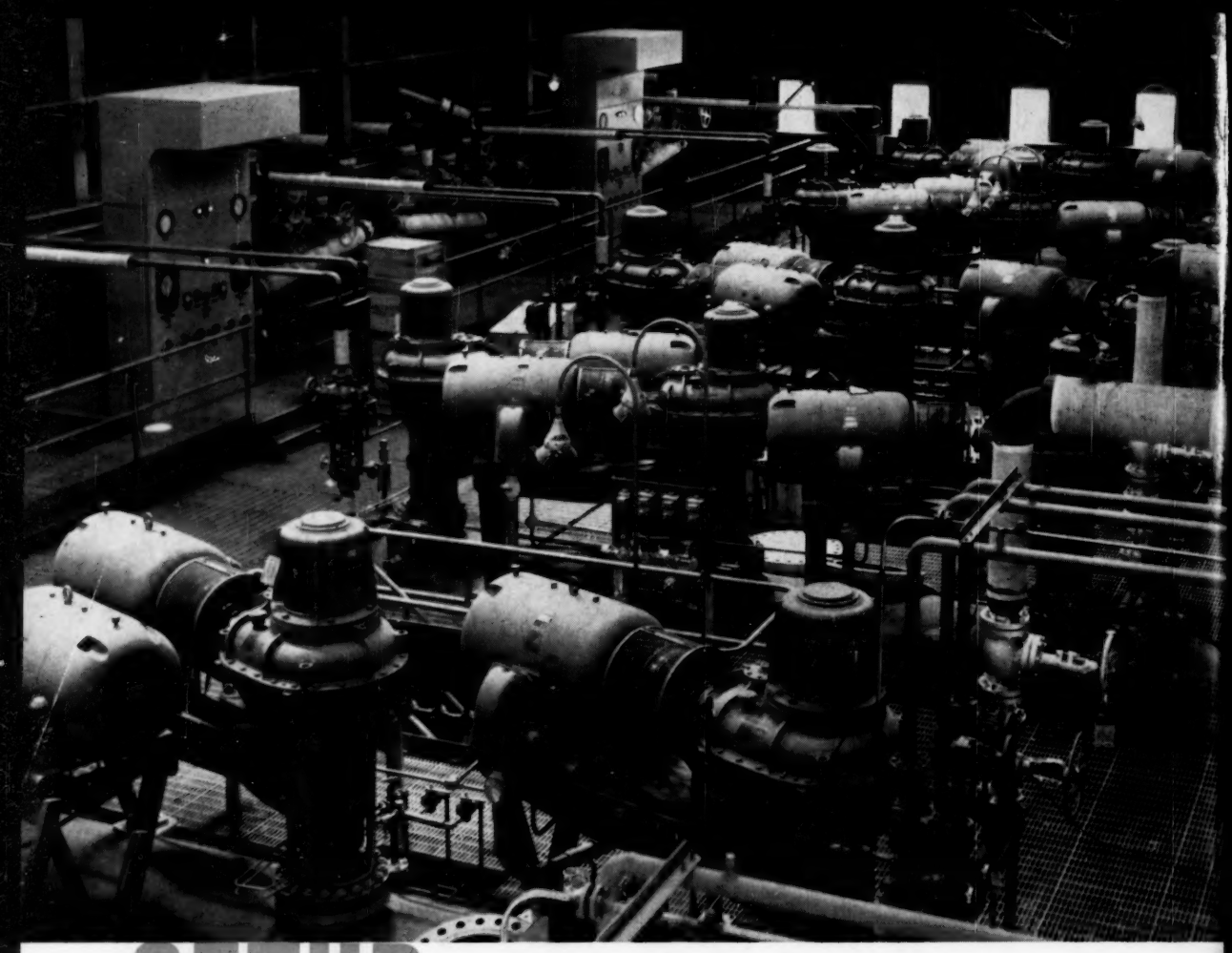
Simplified Packingless Design . . .

Rugged Construction

Every Wilfley installation pays off in lower pumping costs and higher output. Whether you are pumping corrosives, hot liquids or mild abrasives, there's a Wilfley Acid Pump to do the job for you — efficiently, economically.

Pumping parts are available in a variety of metal alloys, as well as plastic, to cover a wide range of corrosive applications. 1″ to 8″ discharge sizes with 10 to 3000 GPM capacities and heads up to 200′ and higher.

Write, wire, or phone for complete information



SETUP for a powerful lot of mixing

Beneath this forest of LIGHTNIN Mixers churns a small ocean of nickel being born.

You're seeing the country's first major refinery of the strategic metal—new 50-million-pound-a-year facility of Freeport Nickel Company in Louisiana. Mixing is a crucial step in the monster autoclaves that reduce nickel-sulphate solution to pure powdered nickel at high temperature and at pressure well over 600 psi.

As hydrogen hisses into the six autoclaves, 18 big dual-turbine impellers grip the heavy slurry and expose every ounce of it to the gas. As pure nickel forms, the mixers keep it suspended uniformly to seed the reaction. New charges of pregnant liquor flow in, and the densification process begins anew.

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Engineers at Freeport Nickel *knew* what their mixing results would be long before they approved these mixers. MIXCO engineers lived with the project for months, checked power requirements by scientific methods, and demonstrated mixing results accurately in scale-model equipment.

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